PHYSIOLOGY AND HEALTH

CONN

BOOK TWO

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PHYSIOLOGY AND HEALTH

BOOK TWO

BY

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PREFACE

When the study of the human body was first introduced into our schools, it was anatomy that was chiefly emphasized. After a generation of experience a change from anatomy to physiology — from structure to function — appeared, and the school textbook became primarily a physiology. Later still it was felt that health — both personal and public health — should be the primary aim of the study of the subject, and textbooks began to put both anatomy and physiology entirely in the background so as to bring to the front problems of health and disease.

In this textbook it has been the endeavor of the author not to lose sight of the necessary knowledge of the fundamentals of physiology and anatomy and to retain the primary essentials of physiology, but at the same time to place large emphasis upon personal and public hygiene. The study of disease seems to have no place in the public schools except in so far as needed to assist the child in appreciating and adopting such a regulation of his life as will aid him in avoiding disease. The preventable diseases, therefore, are freely considered, special reference being given to their prevention, while the non-preventable diseases are either omitted or just mentioned, not discussed.

In early years, the author felt that an apology was almost needed every time he mentioned bacteria and germ diseases. But to-day these subjects hold such a prominent place in

health discussions that no emphasis within the understanding of a child can be considered too great.

The new facts that have been established in connection with foods have changed many features of that important subject. Even the relation of bones and muscles presents a new emphasis to be placed upon certain topics, especially such as relate to properly shaped feet and the results of muscle degeneration. The recognition of neurones as the units of the nervous system, and nervous action and the conception of the brain and spinal cord as a complex of interrelated neurones, has vastly illuminated the study of the nervous system even for younger children.

The advance that has been made in the one subject of hygiene is astonishing. Many essential facts have been so widely verified that it is now possible to state them in the definite, clear-cut form that must be used in the instruction of pupils below the high school age. There is sufficient valuable data to lead to a widespread revolution in the habits of life in this country if those facts could be brought home to the boys and girls in the grammar grades. How they should live; what they should eat; what they need in the way of work and play; why and how they should study — on these points and on many others the teachings are definite and clear. The question now is how to make the facts live in the minds of our young people; if rightly used, they are a rich heritage.

The aim of this textbook is to treat physiology and health in the light of the most recent information possible, to make the facts usable, to present them so simply, so directly, and so naturally as a part of the field of opening knowledge that what his parents know yet disregard the child will believe and follow.

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PHYSIOLOGY AND HEALTH

SECTION I

FEEDING THE BODY

CHAPTER I

WHY WE NEED FOOD

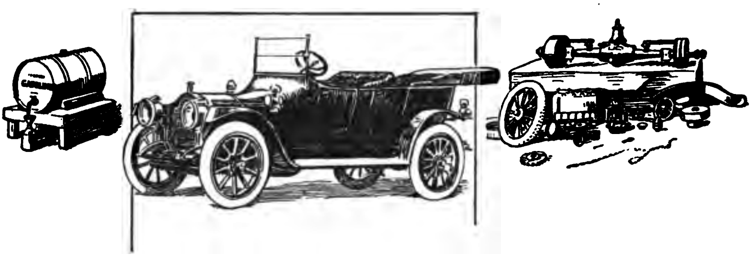
Why We Eat. — We eat because we are hungry; and we are hungry because our bodies need food. Why do they need food? How do they use it? In the first place, our bodies are always in action. We may sit very still, without speaking, without seeming to move a muscle, yet all the time many parts of our bodies are hard at work. There are some parts that work all night and all day, whether we are awake or asleep.

The body has been called the most wonderful of all engines. Engines cannot run without fuel; some burn shavings, others burn coal, for others gasoline is needed. If one wishes to make any kind of engine run properly, he must know with what fuel to feed it; and he must also know what to do when some part of the machine wears out and needs to be repaired.

The Two Kinds of Food. — Unlike other machines, the body gets from the materials fed to it both the fuel

with which to work and the substances necessary for replacing worn-out parts. The body must find, then, in its food: (1) fuel to give it energy for work; (2) materials for making repairs. By "food" we mean only such portions of what we eat as the body can *use* for repair or for fuel. We shall not class as "food," materials that injure any part of the body or that pass out of it as waste.

Foods for Building and Repair. — In comparing the body to a machine, we must notice another difference. A



An automobile needs gasoline for power and a variety of other substances for repairs.

machine is perfected before it begins its work; the body is not. The body of the new-born baby must not only do its work, but it must also build up and perfect its parts — that is, it must grow and develop before it can become the full-sized, perfectly adjusted body of an adult. Nor does it wholly stop growing even when it reaches full size. Certain parts of it, like the hair and the finger nails, keep on growing, and the skin is constantly growing to replace what is worn away. In the grown man, the muscles and bones have stopped growing larger, yet they wear out as they work and so need constant repairing.

Perhaps you had never thought of the bones and muscles as workers, but that is what they are; and they must have food that will repair them.

Fuel Foods. — Fuel foods furnish the body with **heat** and **power**. If we ate no fuel food, the body could not be kept warm, even in a hot room, and with very heavy clothes on. Nor would it have the power needed to move the muscles, or to keep the other parts of the body at work. It could not live. Does this mean that whenever we feel cold we ought to go quickly and get some fuel food? No, indeed; for in that respect our feelings do not count; what counts is the temperature of the blood. Though we may feel cold in winter and hot in summer, the heat of our bodies (i.e. of the blood) is really the same, summer and winter. The normal temperature of the blood is 98.6° F. When it drops below that point, we are ill; and a rise, even of one or two degrees, above that point produces *fever*. We do not need to watch our temperature, however; for if we live right and keep well, it will take care of itself.

Combustion. — By watching the fire in a stove, we get some idea of how the food we eat keeps us warm and gives our bodies power. When the fuel in a stove is burning, we see a flame; it is caused by the uniting of the fuel with a gas in the air (oxygen). This is called **combustion**. In this case it produces both heat and flame. Other substances which burn more slowly give off heat without making any flame. Wherever there is combustion there must be a substance that will burn, and there must be oxygen to unite with it. Fuel foods are burned in our bodies, slowly and without any flame, the

necessary oxygen being taken into the body with the air we breathe.

QUESTIONS

1. What is going on in your body when you are sitting perfectly still? Mention as many things as you can.
2. What are the two uses of food?
3. What is some of the repair work that the body is constantly doing?
4. Does a person's occupation have any effect upon the amount of food required?
5. In what respects is the body a more wonderful machine than the most complicated one that man can devise?
6. Why do you think a child is likely to get hungry more often than is a grown person?
7. If you should place a thermometer in the mouth, what temperature would it show in summer? What in winter? Would the thermometer tell whether you felt warm or cold?
8. Is there any difference in the amount of food required in summer and in winter? Why?
9. What is combustion? Is there any difference between combustion in the stove and in the body? If food is burned in the body, why are there no flames?

CHAPTER II

WHAT WE NEED IN FOOD

Where Animals Get their Food. — It is clear that food must contain whatever is necessary to build (and repair) the body, and to give it heat and power. We speak of matter as divided into three "kingdoms," — mineral,

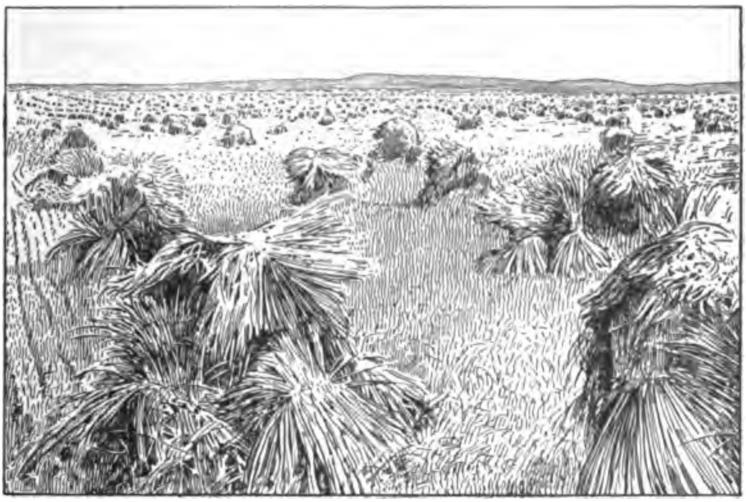


FIG. 1. — A WHEAT FIELD.

vegetable, and animal. The vegetable kingdom derives its nourishment largely from the mineral kingdom; the animal kingdom derives its nourishment from the vegetable kingdom, or from other animals that feed upon plants.

Man is no exception to the rule; he has learned a great deal about minerals and how to utilize them, but he has never discovered how to derive nourishment from them. Like the rest of the animal kingdom, man has to depend for his food either upon the vegetable kingdom or upon other animals. Plants are the only real food factories in the world; they make all the food they need for themselves, and also all the food for the animals.

Three Kinds of Food. — The foods that men use have been divided into three groups; the different members of each group serve the same purpose in the body and have essentially the same constituents, although they may not look alike or taste at all alike. The names given to these groups are:

Proteids
Carbohydrates
Fats

Proteids. — The foods that serve to build up the body, and to keep it in repair, are called **proteids**; without them the body would starve. They can also be used as fuel to a certain extent; but their fuel value is the least important, since we can get our fuel foods in many other forms while we cannot get building material from anything except the proteids.

If you wanted to buy some proteids, you might go to the meat market, to the fish market, to the grocer, to the fruit and vegetable store — they all sell proteids, but you could not get what you wanted by asking for a quarter's worth of proteids. A chemist, if you went to him, would want to know what kind of proteids you

wished, for they have different names when they appear in different substances. The following table gives some of them.

PROTEID IN	IS CALLED	HOW IT LOOKS
White of egg	Albumen	White, transparent, jellylike; heat makes it become solid, *i.e.* coagulates it.
Lean meat	Myosin	Soft and elastic when uncooked; cooking coagulates it, like the albumen in the egg.
Flour	Gluten	A sticky, gummy mass; may be separated by letting water run through a little muslin bag filled with flour.
Milk	Casein	The curd of milk, a thick, whitish substance. To see it in sweet milk, pour in a little vinegar. Cheese is prepared curd.
Peas and beans	Legumin	Similar to gluten. Is also in peanuts.

If we were in a place where we could not get a single one of the substances in the foregoing table, we might still find plenty of proteid, since it is contained in all

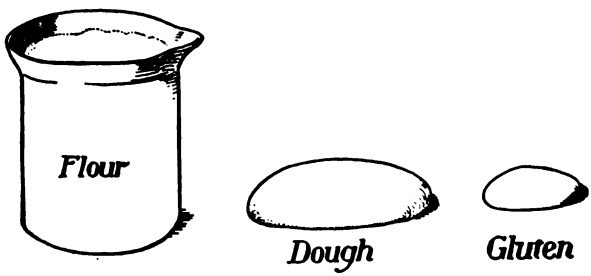


FIG. 2. — WHEAT FLOUR.

Showing the amount of dough to be obtained from a quart of flour, also the amount of gluten to be obtained from the same quantity of flour.

classes of food. The table on page 87 lists the most common foods and gives the amount of proteid in each of them. A glance at the list will show that the largest amount of proteid, per pound, is contained in meat, eggs, cheese, peas, and beans.

Carbohydrates. — The most abundant fuel foods are called **carbohydrates**; these include all *starches* and *sugars*. Sugar and starch seem to us very different, but in reality they are much alike. Nature is constantly busy changing starch into a delicious sugar. That is what happens whenever green fruit ripens, and a similar change happens in our bodies. When we eat starchy food, like potatoes, the starch is changed into a kind of sugar, by a process called digestion. This does not mean that since sugar tastes better than starch we might as well take all the carbohydrates we need in the form of sugar; that would not answer, and the reason why will be apparent later.

The carbohydrates (like the fats) are useful only for fuel; they cannot do any of the building or repairing of the body. But the body requires so much power with which to do its work that more of fuel food is needed than of building food; that is, more of the carbohydrates and the fats than of the proteids. In considering foods, we shall now need to think, not how they taste or look, but which of the food elements they contain.

Starch. — When *starch* is spoken of as a fuel food, we mean starch as it is contained in the vegetables and the grains; to use such substances as food we do not have to separate the starch. Indeed, it is better to eat the whole of the grain than to eat the starch after it is

removed from the grain. The starch in wheat makes it look white, and it gives the white appearance to potatoes and to corn; yet all vegetables that contain starch do not look white. Test this by putting a drop of iodine on a freshly cut piece of potato; if the spot touched turns blue, it means that there is starch there. Now test some of the green vegetables, like spinach and lettuce. Do you find that they contain starch? (If they do, the spot touched with iodine would look bluish.) In the same way test a little flour.

The presence of starch can also be detected with a microscope, for starch is made up of grains, which show very plainly under the microscope. The grains in Figure 3 are of different sizes and shapes, but they can all be easily recognized as starch grains. When we put starch into a little water and boil it, we can no longer find the starch grains; for the heat makes them swell and burst, and the starch becomes a thick paste.

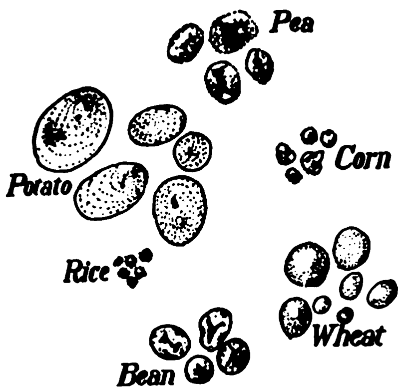


FIG. 3. — STARCH GRAINS FROM VARIOUS FOODS.

Sugar. — In this country sugar is so plentiful that every one knows how it looks and tastes, but there are countries in which it is so scarce that children rarely have any. Most sugar comes from certain plants, and if those plants do not grow in a country, its people have

only such sugar as they can afford to buy and bring in from other countries. The following list gives the sources of our sugars. How many grow in this country?

Name	Obtained from	Comments
Cane sugar	Sugar cane	Cane sugar is prepared in many ways — as granulated sugar, powdered sugar, cut sugar, brown sugar, molasses.
Beet sugar	Sugar beets	Tastes and looks like cane sugar.
Fruit sugar	Grapes and other fruits	Not so sweet as cane sugar.
Glucose	Manufactured from corn and other starchy substances	Much like fruit sugar, and not so sweet as cane sugar.

Milk sugar should also be mentioned; it is obtained from the milk of animals, and is even less sweet than fruit sugar.

Glucose. — One might think that the sweetest sugar would be the best, and would make the best fuel food; but it has been found that all the sugars have about the same food value. That, however, does not prove that they are all equally useful. Did you notice in the list a sugar called glucose, made from starch? It seems wonderful that men should be able to change starch into sugar; and it is only within recent years that manufacturers have learned how to make this change. The glucose that is now made is wholesome, but it is not nearly so sweet as cane sugar. It is frequently mixed with cane sugar because it is much cheaper; by selling sugar with glucose in it the dealer can make more profit. But we buy sugar chiefly for its sweetness. A pound of the mixture will not do as much sweetening as it

ought, and so when people buy it, they are not getting their money's worth.

Fats. — Foods of the third class (fats) are richer in fuel than either the starches or the sweetest sugar. The **fats** and **oils** give about twice as much heat per pound as any other food. Some of them come from animals and some from the vegetable kingdom. The following table lists a few of the fatty foods. Add as many others as you can, and name the source of each.

From Animals	From Plants
Butter	Olive oil
Lard	Cottonseed oil
Tallow	Peanut oil
Blubber	

Notice that the vegetable fats (oils) are in liquid form — they are a part of the juice of the fruit from which they are taken. The animal fats, like the butter and the lard we buy in the market, usually come to us in solid form, but in their original state they are liquid too. The fat of the sheep, from which tallow is made, is a transparent liquid in the living animal; and this is true of the other animal fats.

Fig. 4. — Fat Cells. Obtained from a bit of meat.

The little drops of animal fat are each inclosed in a tiny sac. Figure 4 shows a group of fat cells taken from the fatty part of a piece of beefsteak; these are much too small to be seen without a microscope. One of the properties of a fat is that it will break into tiny droplets if shaken with certain liquids. Put a few drops of olive oil into a small bottle, add some water, put

in the cork, and shake the mixture rapidly. See how it looks after shaking; then let it stand for an hour and note the change. In every glass of milk there are millions of fat drops; when the milk stands, they separate from the rest of the liquid, rise to the surface, and form *cream.*

Mixed Foods. — In order to keep well and strong we must have the three kinds of food — proteids, carbohydrates, fats. The question now is, in what form it is best to eat them and how much of them we need. The answer would be easier if all our foods were not mixed foods; nearly everything we eat contains all three kinds (see Figure 24).

Bread and butter, for example, which most of us eat every day, seems a very simple food; but watch the bread making, some time, and see how many things go into the bread. You will probably find that it is made with flour, milk, lard (or butter), a little sugar, and some salt. There are five ingredients besides the yeast (or baking powder) that is used to "raise" it; and those five contain different food substances. The flour gives a carbohydrate, starch, and a little proteid in the form of gluten; the milk gives another proteid, casein, and a carbohydrate, sugar, and some fat; the lard gives fat, and the butter on the bread adds still more fat; the cane sugar is still another carbohydrate. How many kinds of proteids, carbohydrates, and fats are there in a slice of bread and butter?

Comparative Food Values. — Since plain bread and butter proves to be such a mixed food, we might well wonder whether it would ever be possible to discover how to get the right quantities of the three kinds of food. The

first step is to discover the comparative amounts of proteid, carbohydrates, and fats in our common foods. Much has been done in the laboratories to simplify that problem for us.

The results of these experiments with proteids in various forms are given in Figure 5. The same amount of proteid

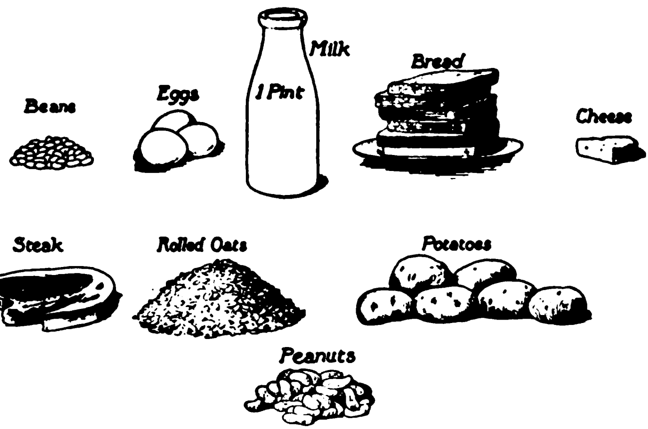


FIG. 5. — FOODS CONTAINING EQUAL AMOUNTS OF PROTEIDS.

The amount of proteid in each of these food portions is the same. For example, 1 pt. of milk contains as much proteid as 2½ oz. of beans, 6 slices of bread, 2 oz. of cheese, 5 oz. of steak, etc.

is found in the various quantities of different foods there represented. It will be seen, for instance, that a small piece of cheese (two ounces) contains as much proteid as is found in six slices of bread or in three eggs and that the proteid in a handful of peanuts is equal to that in five ounces of steak. Similar information has been compiled about the fats and the carbohydrates.

QUESTIONS

1. What is the *original* source of all our food? Can man manufacture food?

2. Mention foods that are good for horses that are not good for men.

3. Mention some animals that live wholly upon plant foods; some that live wholly upon animal foods.

4. Do proteids belong to the animal or the vegetable kingdom or to both? If the latter, give examples.

5. What are proteids used for in the body?

6. What class of foods is especially needed by growing children? Why?

7. What foods furnish fuel for the body?

8. What is the chief article of food in the Eskimo's diet? How do you account for this?

9. What proteids did you eat for dinner? For supper last night?

10. What carbohydrates did you eat for lunch?

11. What makes starch paste thicken when boiled? Do you know of any other food that swells up greatly when heated? What happens when corn is popped?

12. Was there any sugar in your lunch? If so, of what kind was it, and where did it come from?

13. Why do we not want glucose in our sugar?

14. What fats did you eat for dinner and what was their source?

15. What is the difference between cream and butter?

16. How much bread would you have to eat to give you as much proteid as there is in a pint of milk? How many eggs?

CHAPTER III

FOODS WE GET FROM ANIMALS

Sources of Foods. — Comparing plant and animal foods, it may be said that animal food contains more proteid and less carbohydrate; plant food, more carbohydrate and less proteid. Both contain fats. The principal foods that are supplied to us by animals — meat, eggs, and milk — are rich in proteid, but they are much more expensive than the plant foods that also give abundant proteid.

Proteid in some form is absolutely essential to life; it may be used in the body as fuel as well as a building food. This statement might suggest that a diet of proteids alone would be the most desirable, if one could afford it; but that is far from being the case, for too much proteid is almost as bad as too little. We shall later learn the reason for this, and also why plant proteids, being cheaper, are not universally used as substitutes for the more expensive animal proteids.

Milk. — Think how many months a baby grows larger, and gets strong and fat, with no food except milk. Milk evidently must contain all that the baby needs, in the right proportions. Look down the table on page 87 for a food that contains proteid, carbohydrate, and fat in nearly equal proportions; the only one that meets these requirements is — milk. The *curd* (which we know as

casein) is the building food; the *cream*, which is a fat, is a fuel food, as is also the *milk sugar*, which is a carbohydrate.

When the baby becomes more active and begins to walk, he needs more fuel food than there is in milk. Then he can use up force faster than a milk diet will supply it, and so he needs starchy foods, like bread, crackers, and other cereals. He also needs less milk when he begins to eat solid food. In fact, we ought always to think of milk as a food and not as a drink to be used in the place of water.

Butter contains little of food value except fat. It is made by separating cream from milk and churning the cream until the butter forms; this leaves a liquid called *buttermilk*.

The milk from which the cream has been taken, called *skimmed milk*, looks blue and thin, and people sometimes throw it away thinking that it has no food value. Cream looks rich and strengthening; but the fact is that the cream is much less valuable to us as a food than skimmed milk. The latter has just as much of building food (proteid) as before it was skimmed and nearly as much sugar; what it has lost is part of its fat. Those who want to get the most for their money, by buying good food as cheaply as they can, ought to consider how they can make use of skimmed milk, which is really both cheap and valuable.

Another form in which we use milk is as *cheese*. Cheese is made from the curd of the milk by separating, pressing, and preparing it in various ways. There is great food value in cheese when properly used, for it contains all the proteids of the milk and most of the fat.

Milk Needs Care. — If we all lived where we could have our own cow, keep her in a clean barn, and milk her twice a day, with spotlessly clean hands; if we could take the milk to a clean milk room, put it into clean pans, and keep it there at the right temperature until time for the next meal — then there would be no necessity for thinking about the harm that may come from unwholesome milk. Nor would there be as many sick babies. But most of us have to get our milk from a dealer. Dealers and milkmen cannot realize how much sickness and suffering they might prevent by greater care in handling milk; for if they did, they would certainly be more careful.

When milk is dirty, we cannot see the dirt as we see smuts on our faces. Occasionally we may notice some specks in it, but the danger comes from the kind of dirt that can be seen only with the microscope. There are various disease germs that may easily get into milk; some float in the air, others may be on the hands of the milkers, or in the utensils used. These germs are too small to be seen, but they can do much harm. Milk may carry germs that cause very serious diseases, like typhoid fever, scarlet fever, and tuberculosis (consumption). Many people die every year of old age, but more than twice as many die from the results of drinking dirty milk; and it produces much sickness besides, for many of the illnesses that come to babies and young children in summer are caused by germs in the milk they drink.

What can we do about it? If we live in the country, we can visit the dairy from which our milk comes, and see whether everything possible is done to keep the milk

clean. Then we can make sure that good care is taken of it when it reaches us. As soon as the milk is delivered it should be put into dishes that have just been washed in boiling water and should be placed immediately in an ice chest where it will be kept cold until it is used.

Why Pasteurize Milk. — Those who live in cities cannot know much about the source of their milk supply, but they can refuse to use milk until it has been made safe by a very simple process, called **pasteurization.** This consists in heating the milk to a temperature of 145°, allowing it to stay at this temperature for half an hour, and then cooling it. This exact amount of heat, it has been found, will render harmless the disease germs that may be in the milk, without injuring the milk in any way, or changing its taste.

Some cities now require that all their milk (except Grade A) shall be pasteurized before it is sold, thus protecting the public from much danger. Cheap milk is always poor milk; it is likely to be adulterated with water, which can easily be done without the knowledge of the purchaser and, because it is carelessly handled, is most likely to contain harmful germs. It is very dangerous economy to buy cheap milk; it is better to pay a cent or two more a quart for safe milk than to buy milk dipped out of a big can that is kept standing around in a store, and then pay doctor's bills because the milk has made us sick. Milk that is bottled and sealed before it is shipped is much safer.

Meat. — All kinds of meat are alike in one respect: they all consist of lean substance (or flesh), some fat, and considerable water. It is the proteid of the flesh (find

its name in the table on page 87) that makes it a valuable building food. A juicy porterhouse steak may suit our taste better than round steak or a piece of chuck steak, but the cheaper meats are as nourishing as the expensive cuts; they give us more building food for the same money. The skill of the cook is shown by her ability to prepare the cheaper cuts of meat so well, by long and careful cooking, that we shall enjoy them.

Dangers in Meat. — Meat, like milk, sometimes contains hidden dangers. Spoiled meat, which can usually be detected by its color and odor, is dangerous because of the poisons that are formed in it as it spoils. We have eyes and nose to help us in detecting that trouble, especially before the meat is cooked. But there are other troubles that we cannot see or smell.

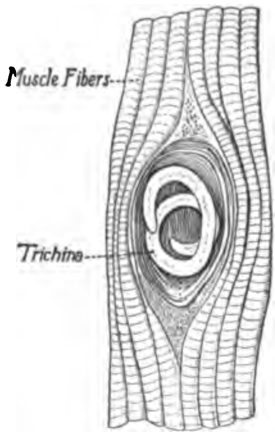


Fig. 6. — Trichina. Showing the animal in a bit of muscle tissue, highly magnified.

In the flesh of pork, even when it is perfectly fresh, there are sometimes tiny worms, called **Trichinæ.** They are too tiny to be seen without a microscope, but if a person swallows them, they may make him very sick or even cause his death. There is a larger worm, called **tapeworm**, that is sometimes found in both pork and beef. This is not so dangerous as the Trichina, but it causes discomfort and sometimes makes one ill. When meat is well cooked, there is no danger from tapeworm or Trichina.

Eggs. — When the chicken hatches out of its shell, it has bones, and flesh, and fat. Where did it get them? Evidently the materials to form them all must have been in the egg, for the chicken has had nothing else on which to feed. So it should not surprise us to learn that eggs contain proteid (albumen) and fat as well as a little material for bone making. One peculiar thing about eggs is that we get the greatest food value from them when we take them raw. When they are cooked, the albumen in them is hardened, which makes them less easy for the stomach to digest. So the less they are cooked the better; and the harder they are cooked the more important it is that we should chew them very fine.

QUESTIONS

1. Which contains the more proteid, meat or bread? Which contains the more carbohydrates? How do peas compare with meats in these respects? Which is the cheaper food?
2. Can you give any reason why milk is the best food for babies? Why is it not an equally good food for grown people?
3. Does skimmed milk contain less building food than whole milk? Does it contain less fuel food? Of what kind?
4. Describe the process of pasteurization.
5. Why is it poor economy to buy cheap milk?
6. Are there any laws in force in your state or community in regard to the care and distribution of milk? Give reasons for such laws.
7. Why are raw eggs so often recommended to people who need to be "built up"?
8. What dangers are avoided by cooking meat?
9. If you had a dollar to spend for a meal for four persons, how could you spend it economically?

CHAPTER IV

FOODS WE GET FROM PLANTS

SOME people live entirely on plant food, and we all get the greater part of our food from plants. When you sit down to dinner to-day, notice how little you would have to eat if you took nothing that contained any of the grains, no vegetables, and no fruit.

The Grains, or Cereals. — This country raises a great many **cereals**; enough to feed our own people and to sell millions of bushels to other countries. Our principal cereals are *wheat*, *corn*, *oats*, *rice*, and *rye*. When they are ground into flour, we have: from wheat, three kinds of flour — *white*, *whole-wheat*, *graham;* from corn, *corn-meal* (sometimes called Indian meal); from oats, *oat-meal*, and from rye, *rye meal*. We do not generally use rice in flour form, but in some countries it is prepared in that way as well as in a number of others.

All cereals contain from six to ten times as much fuel food as building food. Wheat is one of the best cereals for constant use, since, in addition to starch (fuel food), it contains more building food, **gluten**, than most of the others. Under the microscope the starch cells and the gluten cells look entirely different; Figure 7 shows how the microscope sees a small bit of a grain of wheat; showing both the starch and the gluten (proteid) cells. Wheat and gluten look just as different from each other

when seen in oats; only in oats there is a larger proportion of gluten, and more fat. Do you see why people can live and keep well on a diet of oatmeal alone? Rice contains less proteid and less fat than wheat, and more starch. Corn meal is richer in fat than any of the other cereals, except oatmeal.

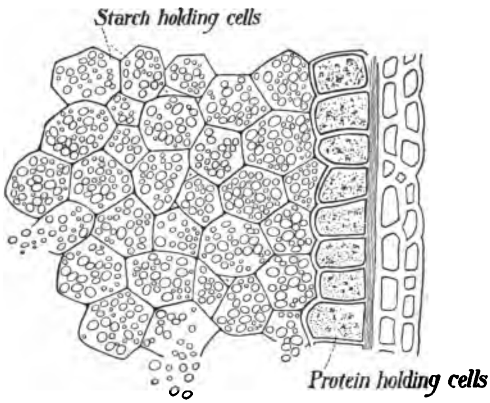


FIG. 7. — WHEAT STARCH AND GLUTEN.
Showing the location of the starch and the gluten (protein) cells in a grain of wheat, highly magnified.

Wheat Flour.—If you were to raise wheat and take it to the mill to be ground into flour, would your flour look like the white flour the grocer sells? No, it would be darker in color and coarser; the bread made from it would taste good, but it would look dark, somewhat like the bread that is commonly used by the peasant of Europe. It would be dark because it would contain the outer husks of the wheat. In order to make flour as white as possible, millers have found an ingenious method of taking wheat grains to pieces; they remove the husks and grind into flour only the central kernel of the wheat. Flour so made contains nearly all the gluten in the grain; but it has lost the minerals and some other materials necessary for perfect health which are found in the wheat husk. In making graham flour and whole-wheat flour the husks

are ground with the kernel, and so these flours are more valuable and healthful than white flour.

Beans and Peas. — The cereals are the most valuable vegetable foods. Next to them come the legumes — peas, beans, and peanuts, which are really a kind of bean. They are excellent substitutes for meat and, all things considered, are more valuable than meats. A larger amount of proteid is contained in a pound of beans than in a pound of meat, and the beans are much cheaper. The legumes are also rich in starch. People who live and work outdoors thrive on them; those who lead an inactive life sometimes find them rather hard to digest.

Fruit and Vegetables. — If the common foods were listed, putting at the head those that are rich in proteid, starch, sugar, or fat, most of the vegetables and fruits would appear far down at the end of the list! Fruits contain some sugar and little else except water; most vegetables are seventy-five to ninety per cent water. We need them because they have their own office to perform: they stimulate the appetite; they give a relish to more substantial foods; they help to keep the organs of digestion from becoming sluggish; and then they do something else that is not yet really understood, even by those who make a study of food. Sailors who go off on long voyages find that unless they have some fresh vegetables or some fruit juices they are likely to get a disease called *scurvy*, from eating nothing but canned and cooked food. So the body evidently needs something that is found in fresh fruits and vegetables.

There are some vegetables, like potatoes, parsnips, and beets, that contain enough starch or sugar or pro-

teid to rank as foods — besides serving the special purposes mentioned above. Potatoes contain only a little proteid; they consist largely of water and starch. When we eat butter on them, we supply fat; in order to get the necessary proteids with them we should eat meat or milk or cheese or one of the legumes.

Nuts. — Almonds, walnuts, and peanuts are just about as rich in protein, per pound, as peas and beans. The peas and beans, we have learned, also have much starch. There is comparatively little starch in these three kinds of nuts, but they have a great deal of fat. Unfortunately nuts are hard to digest; for that reason we are advised to eat sparingly of them and to chew them very fine.

Foods for the Brain and for the Bones. — Certain foods are widely advertised as brain foods. They will appeal only to those who do not understand that the brain needs exactly the same food as the muscles and the other parts of the body. Any food that nourishes the rest of the body will feed the brain; there is no need of buying any special food for it. The so-called "brain foods" are usually much more expensive, but not more valuable, than oatmeal or cracked wheat.

Nature has also made adequate provision for material to build the bones. Part of the bone is made of proteid, which we eat in some form every day; the mineral matter of the bone is lime, and there is a sufficient quantity of lime in our common foods, such as meat, bread, milk, and eggs. So the child who eats these common foods gets all the bone-making material that he needs. He will get little "bone food" from cake and none from candy.

QUESTIONS

1. What countries use rice as the chief article of diet?

2. What cereals are most used in this country?

3. From a study of the table on page 87, would you think that wheat or oatmeal would be the better cereal to use alone as an article of diet? Why?

4. Why is graham flour a more valuable food than white flour? Which contains the more proteid?

5. Why can beans be used as a substitute for meat? Can you think of any objections to using them?

6. Can you think of any good reason why meat and potatoes go well together as a meal?

7. Which would be the better to use together at a meal, potatoes and rice or potatoes and beans? Why?

8. What kind of food should we eat for brain food? What kind to build bones?

9. Make out a menu for what seems to you a well-balanced meal which shall consist wholly of plant foods.

10. What mistakes do people often make in selecting the different articles of food which go to make up a meal?

11. Will a diet of fruit and vegetables furnish the body with all it needs? Give reasons for your answer.

12. How do the following materials compare as foods: celery, lettuce, peanuts, apples, cheese, bacon, olive oil, potatoes, peas?

13. Why is macaroni and cheese a nourishing dish?

14. Name all the kinds of sandwiches you can think of. Which are the most nourishing for you to bring for lunch?

15. Make out a list of the best foods to take with you on a week's camping trip.

CHAPTER V

THE PURCHASE AND CARE OF FOOD

Doing the Marketing. — Every one should know how to buy food, and how to take care of it. To do the "marketing" properly requires study and much care. Think of the amount of money that the people of the United States spend for food every year: about $15,000,000,000. Ought it not to be expected that those who have the spending of all that money shall know how to get full value for it?

Some people think that if they pay the highest price for everything they are sure to get the best; that is a great mistake. The most expensive cuts of meat are no better foods than the cheaper cuts. Skimmed milk is one of the best foods and one of the cheapest. When it comes to the selection of fruits and vegetables, most of them have their "season" when they are at their best, and being most plentiful, are also cheapest. Since grapes are cheapest (and best) in October, would that not be a foolish time to buy oranges, which are just beginning to come into the market, and so are very high? What about buying grapes in January, when the oranges are at their best? In some markets eggs are separated according to the color of their shells. If strictly fresh brown eggs were selling at 30 cents a dozen, and strictly fresh white eggs at 40 cents a dozen, would it be sensible to pay the extra 10 cents for those with the white shells?

Impure and Adulterated Foods. — We buy some foods after they have been cooked or prepared; it is then more difficult to tell whether they are pure. There is always a demand for "cheap goods," even when it comes to foods. Some dealers meet this demand by adulterating their foods — to **adulterate** a food means to mix with it some substance that seems like it but is less expensive. The added substance is not always healthful; sometimes it is one that we should not be willing to eat if we knew what it was; sometimes it is harmless, but has no real food value.

Adulterated Foods are Expensive. — If the best coffee was 25 cents a pound, would you be gaining or losing if you bought a can of ground coffee at 20 cents which was $\frac{3}{4}$ good coffee and $\frac{1}{4}$ ground beans? You would get no food value from the beans (coffee is not cooked long enough to cook beans), and besides they would spoil the flavor of the coffee. Or suppose you were given granulated (cane) sugar that was adulterated with glucose. The sugar would not be so sweet, and you would find that you had to use more of it to get the same result; then the sugar would really cost you more than if you paid more but bought pure sugar. Or you might buy milk that had been adulterated by mixing it with water; pure water is harmless, but it comes high at the price of milk, 6 or 8 cents a quart. Honey is adulterated with glucose; chocolate is adulterated with starch; pepper is mixed with flour, charcoal, and sawdust; it is even possible to make delicious-looking and palatable jellies and jams from apple cores, by using coloring matter and flavoring.

Some Rules for Buying. — Those who buy food should remember:

1. The cheaper grades of cooked or prepared foods are more likely to be adulterated than the better grades.

2. Canned foods are easily adulterated, especially minced meats or anything else that is cut up fine. Cheap grades of canned goods are very likely to be adulterated with some cheap and usually worthless material.

3. Adulterated canned goods are really more expensive than the better grade of goods, because they give less food value.

Spoiled Foods. — Many dried foods may be kept in good condition for a long time, but moist foods are sure to "spoil" if they are not given proper care. The way to take care of them is to protect them from the bacteria in the air. These tiny plants are always present in the air, outdoors and indoors. When they get into moist food, they begin to feed on it, and then they multiply very rapidly. Soon they produce disagreeable changes in the food, which we call molding, or putrefying. Putrefied or decayed food is not only unpleasant to taste and to smell, but it is actually dangerous, because the bacteria that grow in it sometimes produce deadly poisons, called **ptomaines**. Those who eat food in which ptomaines have been formed are likely to become violently ill within a very short time.

Ptomaine poisoning is characterized by vomiting and diarrhea — which result from the effort the body makes to get rid of the deadly poison as quickly as possible. Spoiled fish, cheese, ice cream, and meat are the most frequent causes of ptomaine poisoning. It is not possible

to detect the presence of these poisons in food, either by smell or by taste; but at least we can make it a rule not to eat any food that we have reason to fear may be spoiled.

Importance of an Ice Box. — There are so many bacteria in the air that it is almost impossible to keep them out of food; we can, however, prevent their harming it. The best way to prevent their injuring our food is to keep the food very cold. In summer, milk, butter, meat, fish, and all moist food, cooked or uncooked, should be put into the ice box just as soon as they are taken from the table — no standing in a warm kitchen or pantry until it is "convenient" to put them into the ice box. Even in winter it is not safe to keep them where it is warm. This is particularly true of milk, which in warm weather gets unwholesome after a few hours in the open air, but may be kept much longer in an ice box.

If a household has no ice box, the only safe plan in hot weather is to purchase in small quantities such food as is likely to spoil, securing it from a reliable dealer who keeps it well iced; then have it eaten immediately, before it has a chance to spoil.

Cold-storage Food. — Most large cities have cold-storage warehouses. In these immense buildings food is packed away at the season when it is abundant for use at the season when it is scarce. The temperature in them is kept down almost to freezing, and sometimes below that point, thus preserving the food as long as it remains in the warehouse. Dealers who handle cold-storage food are obliged, in many cities, to hang up a sign stating that fact, and to tell customers what they are buying. That is not because cold-storage food is necessarily unwhole-

some, but because it must be eaten at once, for it is likely to spoil very quickly.

Preservatives. — In order to keep their food from spoiling, manufacturers sometimes put into it certain chemical substances called **preservatives.** This is especially true of sauces, catsups, and other foods likely to be exposed to the air. For sauces, benzoic acid is commonly used, and for other foods borax, salicylic acid, and formalin are employed. These are all poisons, as is shown by the fact that they kill bacteria or keep them from growing; to be sure they are mild poisons but they are harmful in foods. Another way in which some of these preservatives are used is in meat that is beginning to decay (and for this reason is cheap); their use prevents the offensive tastes that would warn the consumer that the meat is unfit for food. Sauces, meats, fish, milk, and canned goods are most commonly preserved in this way. The cheaper grades are always the ones most likely to be "preserved."

Pure Food Laws. — It is quite impossible for each individual in our communities to make sure that the food he buys is pure and wholesome. We have to buy what is in the market. Our food comes from such distances that in many cases it is quite impossible for us to know anything about its source. The protection of food becomes, therefore, a public duty which must be controlled by laws. The government has passed pure food laws that make it a crime to adulterate food, or to treat it with preservatives, or to label it improperly. But the enforcement of these laws has to be left to public officials. Food inspectors of various kinds are always on the look-

out to prevent the public from being cheated by adulterated foods, or poisoned by spoiled and "preserved" foods.

Cities also commonly supervise very carefully the conditions under which vegetables and fruits are offered for sale, since these foods are unwholesome when they are overripe or when they are exposed to the danger of harboring germs. Those who offer them for sale are frequently required to keep them covered, in order to prevent their being powdered with dust or visited by insects that might dangerously contaminate them.

QUESTIONS

1. What are some of the ways in which one can economize in marketing without loss or danger to oneself?
2. In the purchase of what kinds of foods is economy unwise?
3. Name some foods that are often adulterated and describe how this is done.
4. What causes meat to spoil if it is left in the air? How can you tell when it is spoiled? What can you do to make the meat keep better?
5. Name some of the chemicals that are often used as "preservatives." Why do manufacturers find it to their advantage to treat food in this way?
6. What is the cause of ptomaine poisoning?
7. Why do we need an ice box in the home?
8. Tell what you know about the care of a refrigerator.
9. Which is likely to be the better way to obtain good meat and vegetables — to go to the market or to order by telephone?
10. Find out what measures have been taken in your community to lessen the danger to the public from spoiled or "preserved" foods.
11. Find out, if you can, which are the safest brands of canned or bottled foods.
12. How soon after a can is opened should the contents be used?
13. Find out from the health department of your town or city what is the grade of the milk which you are drinking.

CHAPTER VI

BEVERAGES

Water. — It is well known that men can live without food much longer than they can live without water. Yet a great many persons who have both at hand, in abundance, eat too much food and drink too little water. There is little danger of drinking too much water unless we drink it too cold or at the wrong time. The worst time to drink it is when we are chewing our food. The expression "washing down the food" describes how water should never be used. We know that we cannot swallow dry food until it has been moistened, but nature has provided the way to moisten it, that is, with the saliva. When we drink water to moisten the food, we defeat nature's plans, which always means that we make trouble for ourselves.

Impurities in Water. — We have learned that the worst dangers in milk are the invisible ones; and that is also true of water. It may look clear and taste pure, and yet be unsafe to drink because of minute bacteria contained in it. Some of these are harmless, and some, when taken into the body, produce disease. So we need to know, as in the case of milk, where our drinking water comes from, and whether it reaches us as clean as it was at the start.

Water from a *deep spring* is almost always pure, unless

the spring is near some foul place, like an open drain or barnyard. ***Wells,*** however, are so easily contaminated that they need to be carefully protected. There have been instances in which many cases of typhoid fever were directly traced to a single contaminated well. In the country a man can guard his own well or spring if he

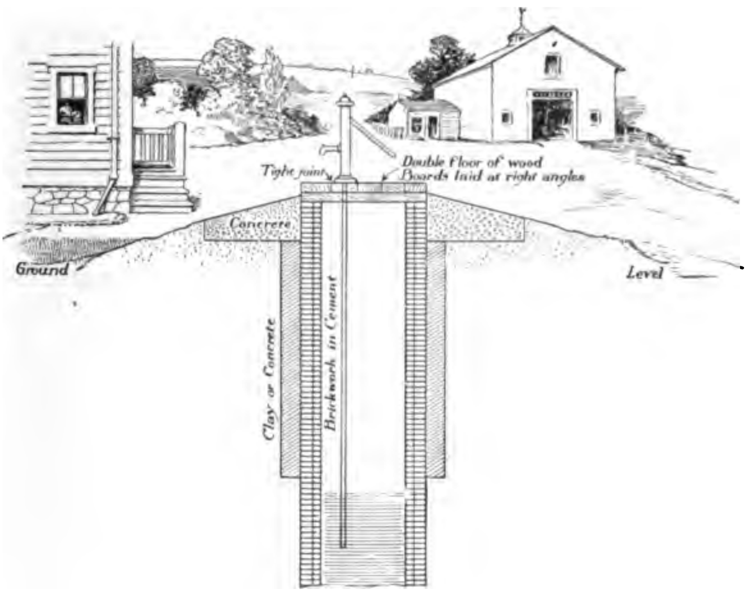


FIG. 8. — A PROPERLY LOCATED AND CONSTRUCTED WELL.

will only give his attention to it. He should remember that the greatest danger comes from allowing the excretions of men or animals to pollute it. There is little chance for pollution if the well is on ground higher than the location of the house and barn. Figure 8 shows a properly located and constructed well. A well like that shown in

Figure 9, which is lower than the house, may easily become contaminated, and hence it is a constant source of danger to those drinking from it.

The most dangerous source of water supply is a river, for most rivers receive sewage from the cities and towns

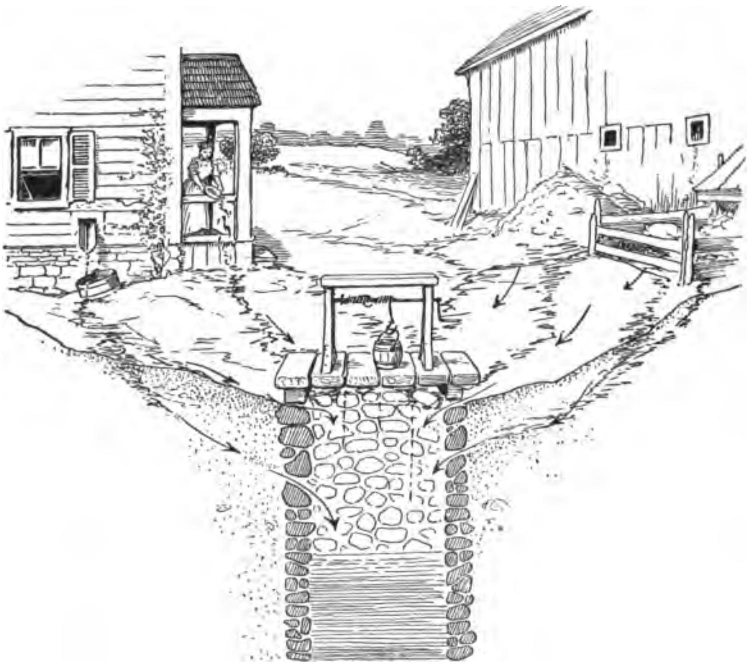


FIG. 9. — AN IMPROPERLY LOCATED AND CONSTRUCTED WELL.

on their banks. Many towns feel that they have a perfect right to empty their sewage into the river.

In towns and cities people cannot have their own springs and wells; they are dependent upon the water the city supplies. Often they know nothing about its source,

and there is nothing they could do to keep it from being contaminated. So cities and towns have to be responsible for taking care of their water supply; how they do this is explained in Section IV, Chapter I.

Other Beverages. — Young people are much better off without either *tea* or *coffee*. How much harm these beverages may do no one really knows, but it is agreed that they do no good, have no food value, and in some cases are actually injurious. *Cocoa* and *chocolate*, on the other hand, are good drinks for young people, especially if they are not made too strong. At soda fountains Americans consume large quantities of "soft drinks"; these quench thirst only because of the water in them. It is an expensive way of buying water; yet such beverages do no special harm unless one takes them too frequently, and then the sirups in them may prove injurious.

Alcohol. — There is one class of beverages which is always harmful and never beneficial; that is the class of alcoholic beverages. In the middle of the last century there were many intelligent people who thought that **alcohol**, in some of its forms, was good for them. They knew that it was made from fruits or from grains, and they thought it must have in it all the "goodness" of the grain or the fruit. So they imagined that it was good for them and for their children.

But doctors found that persons who used alcohol were not so strong, not so well able to resist disease as those who did not use it. Railroad companies discovered that the lives of their passengers were not safe in the hands of employees who took any form of alcoholic drink; so people began to realize that much mischief lies concealed

in alcohol. Then all over the world, in different hospitals and laboratories, men began to study the nature and effects of alcohol.

The Alcohol Makers. — Men knew long ago that if they did certain things to grains or fruits, alcohol would be produced; why it could be made in those ways only they did not know. Finally scientists discovered that alcohol never was produced without the presence of certain very tiny little plants, which can be seen only with the microscope. These plants are sometimes called **yeasts** and sometimes called **ferments.** When they get into fruit juices or into sweet liquids made from grain, they at once set to work on them.

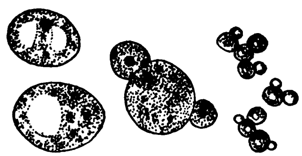


FIG. 10. — YEAST CELLS.
The cells on the left are very highly magnified; those on the right less magnified, but arranged to show clusters formed by budding.

When the yeasts are through their work, they have so changed the nature of the juices that none of the goodness of the grain or the fruit is left. How do they do it? Just by feeding themselves. They are very fond of sweet juices. So when they have a chance, they feed on them; then they grow very rapidly. As they grow they change the nature of the juice; bubbles of gas begin to rise to the top of the liquid, and at the same time **alcohol** is produced. The gas passes off into the air, but the alcohol stays in the liquid. The pure grape juice has been changed into a dangerous drink by the alcohol that has formed in it.

When Ferments Are Harmless. — Where do these sugar-loving ferments come from? Are they dangerous

to us like some of the bacteria that get into water? No, they are commonly quite harmless; in fact they are floating about in the air much of the time. They are on the skin of fruits, and you can even buy them from the grocer. Only you must ask him for yeast; and when he gives you a two-cent cake of compressed yeast, you are buying millions of these tiny plants.

Yeast plants are used to raise bread.

They act upon the bread dough just as they did upon the fruit juices. But the bread is not sweet enough to suit them; so they only make a tiny bit of alcohol which is driven out of the bread by the heat of the oven. In bread, particularly in whole-wheat bread, we get all the good of the wheat; in alcoholic drinks, made from grain, we lose the good of the grain and make a bad exchange, for we get in its place a new and harmful substance, alcohol.

Fermented Liquors. — Even the ferments cannot thrive and go on growing in the alcohol that they make; when they have made a certain percentage of alcohol, they have to stop work. The beverages that they make are named after them, **fermented liquors**. The most common of the fermented liquors are:

Beer and *ale*, made from grains, and containing from 3 per cent to 8 per cent of alcohol.

Wine, made from fruit juices, and containing from 9 per cent to 15 per cent of alcohol.

Cider, made from apples, and containing according to its age from 2 per cent to 30 per cent of alcohol; cider is really an apple wine.

Distilled Liquors. — There is a special process, called

distilling, by which liquors are made stronger (in alcohol) than the ferments will make them. In this process part of the water that is in the liquid is removed; then there is, of course, a larger percentage of alcohol than before. **Distilled liquors** contain from 25 per cent to 55 per cent of alcohol. The rest of the liquor is water with a little

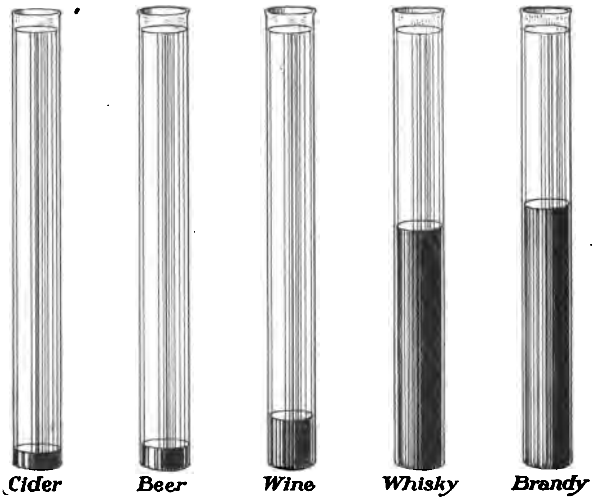


FIG. 11. — RELATIVE AMOUNTS OF ALCOHOL.

The figure shows the relative amounts of alcohol in different alcoholic beverages. The dark portion represents the alcohol, the rest being mostly water.

flavoring matter; the water is the only useful thing in it, since the alcohol is harmful. The most common distilled liquors are *rum*, *whisky*, *gin*, and *brandy* (see Figure 11). Notice how large is the amount of alcohol in such liquors as whisky and brandy.

There is nothing in any one of these beverages that

makes them necessary or even desirable for a person in good health and much that makes them dangerous. To-day many doctors believe they are of no use, even in illness; when used, they should be carefully prescribed, just like other drugs. The boy or girl who wishes to be vigorous, useful, and successful should let them absolutely alone.

The Alcoholic Appetite. — All physicians know that persons "respond" differently to the same kind of medicine. Some can take twice as much of a drug as others without its affecting them; and nobody, not even the doctor, can tell to which class he belongs. It is the same with alcohol. Some people can go along, year after year, drinking such small amounts that the alcohol does not seem to do them much harm. Others are quite unable to do this, for as soon as they take a little, they have a craving that cannot be satisfied except with more and more alcohol. But even those of the first class are never safe: they are really injured by the habit and too often they wake up some day to find that without realizing it they have formed a desire for alcohol that they cannot shake off.

The fact is that the use of alcohol creates a diseased appetite; its effect on the body is such that by and by the man is uncomfortable without alcohol — and all the time it takes more and more of it to satisfy him. A person may be very strong and may at first seem to be able to resist any bad appetite; but this does not give him protection; for all the time the alcohol is undermining his strength. No one is really safe from this danger except the one who never begins to use alcoholic drinks.

QUESTIONS

1. Why should we not wash food down with water? Does this mean that we should not drink water during the meals?

2. When a person experiences difficulty in swallowing his food without taking water or some other liquid with it, what is the reason?

3. How many glasses of water do you drink in a day? When do you drink them?

4. Can you think of any reason why cocoa and chocolate are good for children while tea and coffee are not?

5. What is the source of the water that you use at your home? Who guards it from contamination? Is it pure? What would you do if you suspected it to be dangerous to drink?

6. Why did people formerly think that alcohol was good for them?

7. What will yeast do to fruit juices?

8. Hard cider is sweet apple juice that has been fermented by yeast plants. Where was this yeast before the apples were ground?

9. If yeast is grown in bread dough, why is bread not harmful like beer?

10. Which are the more dangerous drinks, fermented or distilled liquors? Why?

11. Can you think of any good reason why a person should use an alcoholic drink? Can you think of reasons why he should not? What are they?

12. What is meant by the alcohol appetite? How is it acquired?

13. Does alcohol quench thirst?

To the Teacher. Bring a little fresh fruit juice into class. Let pupils taste it. Then let it stand in the room uncovered for a few days and ask pupils to taste it again, likewise observing the changes in its appearance.

Into a small vial pour a solution of molasses and water. Add to it a few drops of yeast (made by dissolving a small piece of compressed yeast in water) and let it stand in a warm place for about twenty-four hours. Then have pupils observe changes which have taken place.

CHAPTER VII

THE FIRST STEP IN DIGESTION

Digestion. — The food we buy must be greatly changed before it can be taken up by the body as nourishment. Cooking makes some changes, but these changes are slight compared with those that take place in the cooked food after we have eaten it. The blood is the food carrier, and, since it will not carry solid bits of food, the bread, the meat, and the potato that we eat must be liquefied before they can be carried over the body. The process by which food, after being eaten, is so changed that it can be taken into the blood is called **digestion.**

The process of digestion begins in the mouth and ends in the large intestine (see Figure 18). At first it is partly under our control; that is, we can do as we like about a certain part of the process. The other parts of it are not under the control of the will. If the part we control is well done, the other parts will be done well too.

Digestion as Team Work. — Digestion is an excellent example of team work. Let us say that a boy begins the play when he sits down to the breakfast table and begins to eat. Before long, he passes the play to others; that is, to parts of his body which know their share of the game and do not have to be told what to do. He is the only player on the team who needs coaching; and

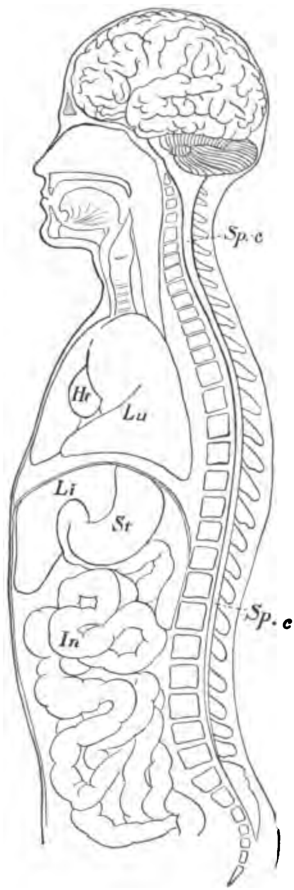


FIG. 12.—A VERTICAL SECTION THROUGH THE BODY.

The location of the important organs is shown. *Ht*, heart; *In*, intestine; *Li*, liver; *Lu*, lung; *Sp.c*, spinal cord; *St*, stomach.

he is likely to interfere with the work of the others, for he cannot see what they have to do or how they do it. In fact, the whole process of digestion was a mystery for many centuries. One part of the process was discovered and then another; whenever a physician had a patient whose digestive organs were markedly abnormal, that case was carefully studied and the conclusions drawn from it were given to other students. So, little by little, many marvels of the digestive process have been found out; other parts are not yet fully understood.

What Chewing Does for the Food. — Dr. Horace Fletcher was much interested in food and made many experiments upon himself. He found that when he chewed his food a long time, he was satisfied with less to eat, and he concluded that long chewing enabled him to make better use of what he ate. However that may be, all doctors are agreed that our food should be thoroughly chewed before it is

swallowed. The stomach works only on the outside of the pieces of food we give it. When we chew a piece of bread until it is divided into hundreds of little bits, then the stomach has hundreds of pieces on which to set to work. It can do its work much faster and easier that way than when we give it a few big lumps. If a person is in a hurry and does not chew his food well, then the stomach has to try to make up for his carelessness by working harder than it should. The result is the same as when one member of a team fails to do his work properly.

FIG. 13. — THE SALIVARY GLANDS.

Solid food ought not to be swallowed until it is ground into a fine pulp. While that preparatory grinding is going on, something else is also taking place, which forms the first step in digestion.

Saliva Starts the Digestion of Starch. — When we begin to eat, our mouths become moist with a fluid called **saliva.** This is produced by three pairs of glands; two of them are under the tongue and another pair on the sides of the face in front of the ear (see Figure 13). All of these glands have openings into the mouth. They are most active while we are eating; sometimes even the sight of food sets them to doing extra work. When we say that the thought of food "makes the mouth

water," we are saying that it makes the **salivary glands** active. Every day they produce about a quart of saliva; most of it is used to moisten the food; some of it is needed between meals to keep the mouth and throat moist.

Water a Poor Substitute. — Water will moisten food too; we can eat much faster if we drink as we eat. But the water cannot make the changes in the food that are produced by the saliva. If you soak a bit of bread in water, it gets soft and soggy but otherwise it tastes the same as before. If you chew a piece of bread fine, until it is moistened with saliva, it begins to have a sweet taste. That is because the saliva has begun the digestion of the bread by changing some of the starch into sugar. Saliva does not act in this way on any except the starchy foods, but, as we shall see later, it is important that the work of digesting starch should be well begun before it reaches the stomach. If we use vinegar on our food, we make it sour, and that greatly interferes with the digestion of starch in the mouth.

Athletes who are working hard use chewing gum to increase the amount of saliva in the mouth. In ordinary life, this is neither necessary nor desirable. Continuous use of chewing gum is actually harmful; for it forces the salivary glands to work overtime and thus unfits them for their regular work.

Secretion of the Saliva. — Excitement of any sort will often interfere, temporarily, with the secretion of saliva. We all know that when we are badly frightened our mouths feel dry; that is because the fright has stopped

the action of the salivary glands. An amusing use was once made of this fact. A man who was convinced that one of his servants was a thief called all his servants together and told them about his losses. Then he said that he was going to give each of them a mouthful of dry meal and that those who were innocent of the theft would be able to swallow it while the thief could not. That was exactly what happened; one of the servants was utterly unable to swallow the meal and he confessed to being the thief. He had been so frightened lest he should betray himself that the fear had stopped the secretion of saliva and he could not moisten the meal sufficiently to swallow it. The other servants not being guilty were not afraid and had no difficulty in swallowing.

Eating in a Hurry. — There are evidently good reasons why we should chew our food well, taking plenty of time to eat each meal; half an hour is none too long when the meal consists of solid food. But what can we do when we are in a hurry? We should eat slowly even though that may involve eating less than usual. A little food, properly eaten and relished, will do more good than a full meal that has to be "bolted."

The fire in a wood stove has to be tended constantly, or else it will go out. Is it the same with our bodies? Are we in danger of having to stop work some afternoon for lack of strength, in case we do not have time to eat the usual amount of food at our midday meal? Fortunately, we are not. In fact the food that we eat at noon to-day is not really used by our bodies before to-morrow — so much has to happen to it before it is ready

to give us energy and heat. If you are obliged to cut your midday meal short to-day, eat slowly as much as you have time to eat; then at the next meal you can eat a little more than usual, if you need it, to make up for the meal that you had to cut short.

FIG. 14. — He had better take his lunch with him than to eat it in this way.

Drinking Water with Meals.— Drinking water with meals has been considered unwise, on the theory that the water would so dilute the digestive juices that they could not work as vigorously upon the foods. That seemed a reasonable conclusion until it was put to the test. Recently careful tests have been made by giving a number of healthy young men a certain amount of food for several days; one day they were given with it only a small quantity of water, the next day they were given large quantities of water. Most careful studies were then made as to the digestion of the food. After many tests of this sort it was clearly proved that food is better digested and ab-

sorbed when considerable quantities of water are taken with the meals.

The earlier belief that water checked digestion was thus proved to be a mistake, but that does not warrant its use in the wrong way. We should not drink with each mouthful to save the time and trouble of chewing food. Water makes a good "last course" at any meal, and it is all right *between* mouthfuls but not *with* them.

The Kind of Relish That Helps Digestion. — It has been proved by many experiments that when we enjoy eating a meal, it is better digested than when we are indifferent to it, or when we make a fuss about having to eat some dish we do not care for. This means that we ought to learn to like various kinds of foods; it is possible, for you will find that people who have traveled much, in various parts of the world, eat and enjoy eating a great variety of dishes. We should also cultivate the habit of being cheerful at mealtime and of talking only of pleasant things.

Good Teeth Help Digestion. — The teeth are a set of tools, of different sizes and shapes, to be used in preparing the food for digestion in the stomach. The front teeth have sharp edges for biting food; those just back of them are better for tearing it; those still further back have broader surfaces for grinding the food into a fine mass. Tools always have to be taken care of if they are to do good work. If the teeth are in good condition, chewing the food is a pleasure; when they are decayed, a person is inclined to spare them and thus to throw part of their work on the stomach; this paves the way for indigestion.

Bad teeth, besides making the mouth look unsightly,

give one a foul-smelling breath, and they may be the cause of sores in the mouth. So it is a matter of great importance that the teeth should be kept in good condition. Some cities have the teeth of the school children inspected at regular intervals. That is because they have found that when bad teeth are put into proper

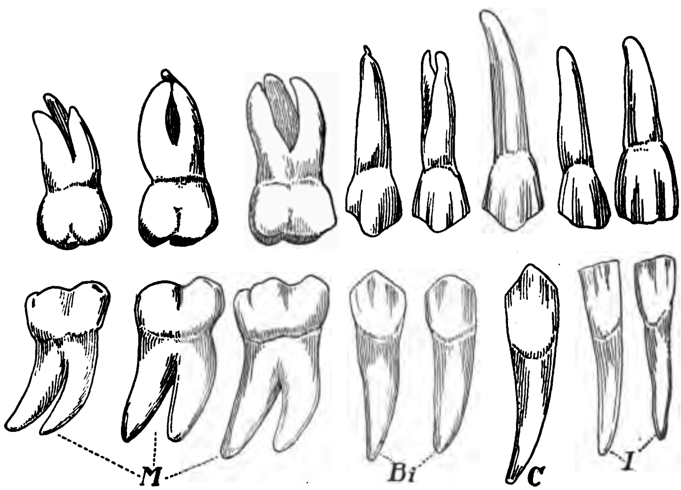


FIG. 15. — THE TEETH OF AN ADULT.
C, canine teeth; *Bi*, bicuspids; *I*, incisors; *M*, molars.

condition, a pupil often improves not only in his general health but also in his class work.

How Teeth Are Injured. — The outside of a tooth is very hard, but it is also brittle, like glass; the inside is much softer. As long as the hard outside, called **enamel,** remains unbroken the tooth continues to be sound and healthy. If the enamel is cracked, so that the food we

eat and the fluids of the mouth come in contact with the softer bone within (dentine), it is likely to begin to *decay*. The crack in the enamel may be a tiny one, but inside the tooth the trouble will spread, until it is necessary to cut out some of the soft part of the tooth (pulp) to stop the decay. When that is done, the dentist puts in some kind of "filling" that is suitable to take the place of the soft part he had to cut away.

Picking the teeth with needles or pins may scratch the enamel, and the result may be a crack in the tooth. The same thing is likely to happen when nuts or other hard substances are cracked with the teeth.

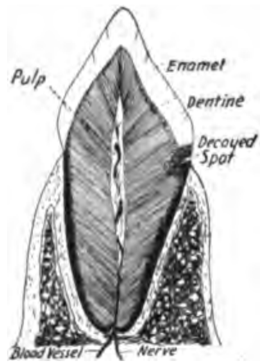


FIG. 16.—A SINGLE TOOTH. This figure shows the relation of parts and also the formation of a decayed spot.

Why We Brush the Teeth. — Perhaps most of us brush our teeth because we want them to look and feel clean; that would be reason enough, but there is another reason why we need to do it. When we eat, particles of food lodge between the teeth; if they are not removed, decay of the teeth may start from these food particles. So it is well to brush the teeth after every meal, or at least every night and every morning. A stiff toothbrush is best. It should be used up and down the teeth, as well as from side to side; this dislodges the particles of food between the teeth. It is as necessary to brush the back teeth as the front teeth, and the inner surfaces, next the tongue, need brushing as well as the outer surfaces.

Removal of Food Particles. — Even careful brushing will not wholly remove the food particles; occasionally it is best to use a soft toothpick, or a piece of strong silk thread that can be run between the teeth without injuring them or the gums around them. Dental floss is excellent for this purpose. If we are thorough in this care of the teeth, we can go to the dentist without being afraid that he will find large cavities in them. Every one should have his teeth examined by a dentist twice a year. This applies to children as well as to adults; for if the milk teeth are neglected, the permanent teeth that follow them are likely to be imperfect.

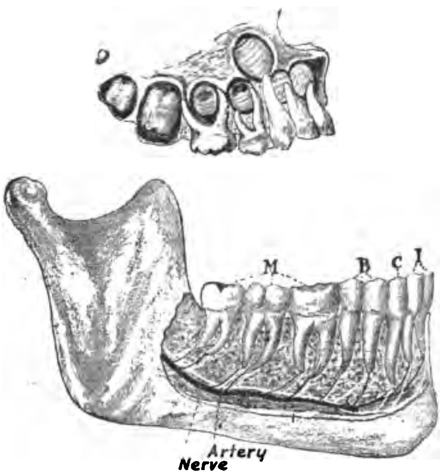


FIG. 17. — BABY TEETH AND ADULT TEETH.

The upper figure shows the baby teeth and above them the adult teeth which are to grow and push out the baby teeth. The lower figure is the lower jaw of an adult.

In the care of the teeth there is one motto to be remembered constantly; if it could be printed so black that every person who reads it would remember it, not only toothache but much illness would be prevented: **A clean tooth never decays.**

The Growth of the Teeth. — Babies are born without teeth. When a child is five or six months old, the first

set, called temporary or *milk teeth*, begin to come through the gums. By the time he is about three years old, he has twenty teeth, ten on each jaw. When he is six or seven years old, the *permanent teeth* begin to appear. They are formed in the jaw above the milk teeth, which loosen to make way for them. In the temporary set there are only two molars on each side of the jaw. The first of the permanent teeth to come through are the "six-year molars." They are often neglected and allowed to decay because they are thought to be the last of the milk teeth. If a child of six or seven has three double teeth on one side of the jaw, the one which came last is a permanent tooth. While the permanent teeth are forming, the child's jaw is also growing larger, so by the time he is eighteen there is usually room for the thirty-two large teeth that make the permanent set. Or it may be that the last four teeth, called wisdom teeth, will not come before he is twenty-five. These teeth are longer and stronger than the first set and with proper care should last for the remainder of one's life.

The Parts of a Tooth. — The part of the tooth that we see is called the *crown;* the part called the *neck* is surrounded by the gums; the *root* fits into the socket in the jaw bone, where it is well anchored. Every healthy tooth is alive and so it has to be fed. Its food comes through a tiny blood vessel which passes up through the root. A nerve also runs through the root; were it not for this nerve, which aches when it is exposed to the air, a tooth might decay so badly that it would crumble before we noticed that there was anything the matter with it. Toothache is a danger signal.

QUESTIONS

1. Why does food need to be digested? What would happen if you could not digest your food?

2. Drop a square of lump sugar into a glass of water. Break another lump into several small pieces and drop them into a glass of water. Watch and see whether the sugar in the first or second glass dissolves more quickly.

3. Would you conclude from this experiment that it is extremely hard work for the stomach to digest a meal that is eaten in a hurry?

4. How long a time do you usually spend in eating your breakfast? Your dinner? Your luncheon?

5. What are the two uses of saliva? Could we swallow any of our foods without saliva?

6. Why does a dog lick his chops when you tempt him with a piece of meat?

7. What precautions should one take when drinking water with meals?

8. Why is it best not to tell any exciting or distressing news at meal-time?

9. Can you see any reason for the saying "Laugh and grow fat"?

10. Why would it not be best to take our food — supposing we could — in the form of tasteless pellets?

11. Can you think of any reasons why poor teeth mean ill health?

12. What are some of the causes of decay of the teeth?

13. What may happen to one's teeth if he uses them for cracking nuts or picks them with a pin or needle?

14. How many people you know have perfectly sound teeth? How have they kept them in good condition?

15. How often do you brush your teeth? What kind of tooth-brush have you? Do you use dental floss?

16. Try to figure out which will take more time: to rinse or brush one's teeth after each meal, or to have one or two decaying teeth filled by a dentist each year. Which is more trouble and expense?

17. At what age should one begin to have his teeth cared for?

CHAPTER VIII

DIGESTION IN THE STOMACH

WE do not eat in order to feed the stomach, it is the other way about; the stomach works from eight to twelve hours every day to do its share toward feeding the rest of the body. We have to tell our hands what we wish them to do, but the stomach does its work without our attention. At the same time we can help or hinder its action. In case we permit ourselves to be ill natured when we are eating, we interfere with the work the stomach wants to do. Another common mistake is to deprive the stomach of its rest. It ought to have a chance to rest between meals, when its work is completed.

Swallowing. — When the food is fine enough to be swallowed does it fall down the throat? No, and swallowing is not so simple a process as it seems. Chewing is under our control, and we also control the tongue as it pushes the food back into the throat, which is the first act in swallowing. But after the food passes into the top of the **gullet** or **esophagus** (the tube that connects the mouth with the stomach) the muscles of the gullet close behind it and send it down, in a series of pushes of which we are not conscious. Even water does not run down the gullet, but is pushed down by the muscles. Did you

ever see an acrobat stand on his head and drink a glass of water; or a horse drinking out of a brook and thus swallowing upwards? A few seconds after we let the water start down the gullet it reaches the gourd-shaped bag that we call the stomach.

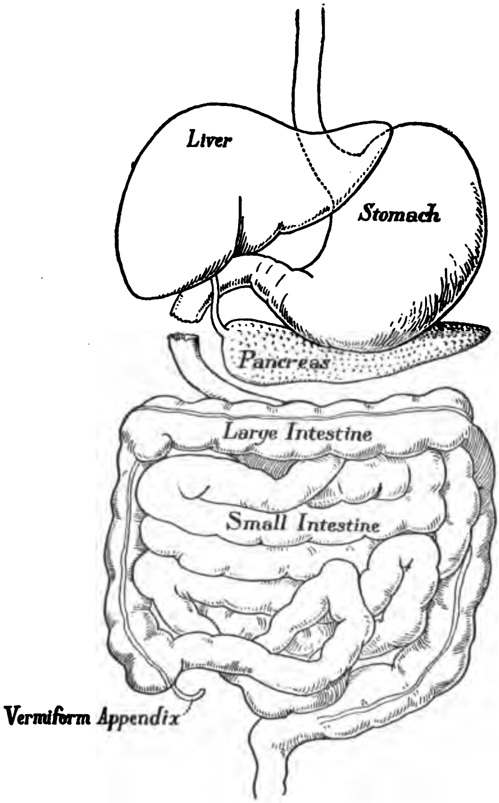


FIG. 18. — THE DIGESTIVE ORGANS VIEWED FROM IN FRONT.

In this figure the liver and stomach are represented as separate from each other. There is in reality no break in the intestine, but it was placed in the figure in order to show the separate organs which in their proper position more or less cover each other.

Location of the Stomach. — The only way into the stomach is through the mouth. Figure 18 shows the stomach, but many a person cannot locate his own stomach accurately, even after studying such a picture. So pupils are advised to consult and to copy the outline figure found on page 360. That shows

how the different digestive organs are situated with reference to each other.

How the Stomach Works. — The entrance to the stomach from the gullet is guarded by a small fold of muscle which acts as a valve and closes behind the food; this, under ordinary conditions, prevents the food from passing back from the stomach to the gullet. In case we eat something that disagrees with us badly, the stomach may finally reject it. Then we have a feeling of *nausea;* we say that we are "sick to the stomach"; and finally this valve opens and the contents of the stomach are "thrown up" or vomited, thus relieving us. There is another muscle fold (the **pyloric valve**) that closes the other end of the stomach and prevents the food from passing out before the stomach has completed its work.

The stomach stretches when food is put into it, and then contracts when the food passes out. Its inside walls have a variety of muscles so placed that they keep the food in constant motion while digestion is going on. Like a churn, the stomach moves its contents back and forth and tumbles it about; there is less motion in the upper part, where the food enters, than in the lower part.

The Gastric Juice. — Besides churning the food, the stomach also pours upon it and mixes with it a considerable quantity of a digesting fluid that is called **gastric juice.** This is made, as it is needed, by thousands of tiny glands (gastric glands) that line the inner surface of the stomach. (See colored insert, page 138.) These glands may be compared to tiny bottles with their mouths opening into the stomach; only the gastric glands, un-

like bottles, make the fluid which drops into the stomach through their open mouths and so is poured upon the food. The amount of gastric juice made in a day would vary, with the person and with the food eaten, from a pint and a half to three pints.

Action of the Gastric Juice on Proteids and Fats. — As soon as the food enters the stomach, the glands begin to pour gastric juice upon it. At the same time the stomach begins its churning motions which mix the food with the gastric juice. Meat, one of the most common forms of proteid, is made up of countless minute threads, called *muscle fibers*, which are glued together into little bundles (see Figure 56). Scattered through the muscle fibers there are also fat cells (see Figure 4) which are held together by tiny fibers; each of these cells contains a little drop of fat.

The first action of the gastric juice is to dissolve the gluey substance that holds the muscle fibers, and also the thread-like fibers that hold the fat drops. Then the muscle fibers fall apart, and the fat drops, also set free, are melted by the heat of the body. The result is that the meat becomes more or less liquid; it begins to be dissolved by the water that is in the stomach. Gastric juice acts in a similar way on the coagulated white of egg, and on cheese and all other proteids.

The Digestion of Milk. — After a hearty meal a baby often throws up part of its milk in a curdled condition. We can watch the curdling process if we put a little rennet into a cup of milk warmed to about 98°, the temperature of the body. Use a teaspoonful of rennet or one of the rennet tablets sold by druggists. In the

course of half an hour the milk will be curdled. Notice that the curd, which is casein, is a solid mass. In the case of the baby, the curdling of the milk does not mean that its stomach is "too sour." It means that the baby has eaten too much, and the stomach cannot hold it all; the fact that the milk is curdled only shows that the rennet in the gastric juice is properly digesting it. If it were not curdled, we should feel sure that something was wrong; for, since the gastric juice is acid and contains rennet, the curdled condition of the milk is an indication that the stomach has been doing its work.

The second action of the gastric juice on the milk curd is to begin to convert it again into a liquid, so that it can be taken into the blood.

Starch and Sugar in the Stomach. — Gastric juice does not digest starch. When we chew starchy foods a long time, we give the saliva in the mouth a chance to begin changing them into sugar; then when they reach the stomach, the saliva goes on working as long as it can. In the upper end of the stomach, which is more or less quiet, the saliva may work for some time; but finally the sour gastric juice makes the starchy food sour, and then the saliva, not being able to work on sour food, can do no more digesting. Nothing further happens to the starch until after it leaves the stomach.

Sugar readily dissolves in water; hence the sugar found in fruits is ready to go into the blood as soon as it is dissolved by the water in the stomach. That is not the case with our highly concentrated cane sugar. Cane sugar has to be changed before the body can use it, but the change does not take place in the stomach.

Watching the Process of Digestion. — One fortunate doctor had many opportunities to watch the process of digestion. A patient by the name of Alexis St. Martin was sent to him suffering from a gunshot wound that had pierced the walls of the stomach. When the wound healed it left an opening into the stomach which was covered by a flap that could be pushed aside. The doctor was quick to see that this gave him a wonderful opportunity to watch a stomach at work. He made observations for several years, noting what kinds of foods remained longest in the stomach, and what kinds were made ready for the intestine in a comparatively short time and how the man's conduct after eating affected the action of the stomach. His reports covered many of the facts that have already been given in this chapter.

Much of what he saw was then entirely new to students who were studying the process of digestion, and because they could not account for some of the things this doctor reported, they began to think that he was not an accurate observer. So as the years went on, and nothing happened to confirm his reports, investigators began to laugh at the elaborate notes made by that doctor; they said that he had used his imagination more than his eyes.

X-Rays of Digestive Process. — Many years later came the wonderful discovery of the X-rays which have made it possible to learn so much about what goes on inside the body. It was found that the progress of food through the digestive organs could be watched if the food was mixed with bismuth, a harmless substance that makes it opaque so that it can be seen by the X-rays. When

the X-ray confirmed much of what the doctor had seen, people began to study his records once more.

Countless experiments have been made with small animals because they are more easily observed. The animals are fed the food they like, plus bismuth, and successive X-ray photographs are then taken. These photographs indicate that an ordinary meal will stay in the stomach of a cat for an hour or two before it is digested well enough to go on into the intestine. But if just after the meal is swallowed anything occurs to frighten or disturb the cat, the stomach ceases to do its work properly and the food will remain in it for hours, without being digested. The fright interferes with digestion by stopping both the secretion of gastric juice and the action of the muscles of the stomach.

Sleep and Digestion. — When the animal goes to sleep right after swallowing a meal, the food stays a long time in the stomach without digesting. It has been observed that babies go to sleep as soon as they have had their milk; from this it has been argued that to sleep after eating was natural and therefore healthful. Evidently it is natural for babies, who ought to sleep most of the time anyway; but it does not follow that grown people, whose habits are very different, ought to take naps after eating. X-ray observations of animals indicate that a nap is likely to delay digestion. Perhaps the baby's sleeping may be explained by the fact that food calls the blood to the stomach, and as the baby has few interests to keep his brain active, he just drops off to sleep when the activity of the stomach calls part of the blood from the brain. Grown people, having more to do and to think about, can easily and naturally keep awake under those circumstances.

QUESTIONS

1. What part of swallowing can you control?

2. How is food prevented from going from the stomach into the intestine before it is properly digested?

3. Does food ever pass from the stomach back into the gullet? Under what conditions?

4. What happens to meat in the stomach? To the white of egg?

5. What happens to starch in the stomach? To milk?

6. If you chew your food thoroughly, where will the digestion of meat begin? How about bread?

7. About how long will food remain in the stomach?

8. Why will food remain longer in the stomach, if the person is irritated or frightened at mealtime?

9. Can you explain how a horse drinking from a brook can swallow up into his stomach?

10. What does the fact that milk curdles in the stomach indicate about the gastric juice?

11. Where is the gastric juice made?

12. Explain how men have been able to learn so much about the process of digestion.

To the Teacher. Artificial gastric juice may be prepared by dissolving ten grains of pepsin powder in a half pint of water and adding about twenty drops of strong hydrochloric acid. Have pupils mix two or three teaspoonfuls of fresh milk with a few drops of this solution and keep at about 100° F. Have them observe and comment upon the result.

Secure if you can and bring to class X-ray photographs.

CHAPTER IX

DIGESTION AND ABSORPTION IN THE INTESTINES

WHEN the food passes out from the further end of the stomach, it goes into the **intestines**, also called the **bowels** (see Figure 18). This food contains much undigested starch; some proteids and fats whose digestion was not completed in the stomach; and all of the cane sugar in undigested form. Much remains to be done in the intestines, which are assisted in this work by other organs. These will be described before we trace the process of digestion further.

Any one who makes small paper models of the organs (see pages 360 and 361) and places them as they lie in the body will get a clear idea of their relations. It is difficult to make this plain in the figures because of the way in which one organ overlaps another.

The Intestines. — Look at Figure 18 and you will see just below the stomach a very much coiled tube. The smaller part of it has many, many folds; the larger part, which goes around the coils, is shaped like the letter U turned upside down. The smaller part, which is connected with the stomach, is called the **small intestine**; it is about twenty feet long and about an inch in diameter. The much-coiled small intestine opens into the larger U-shaped tube, called the **large intestine,**

which is some five feet long and about two and a half inches in diameter. Long as these tubes are, they do not begin to represent the length of the journey that the food has to make before it is either fully digested or sent out of the body as waste. The continual churning of the food in the stomach and intestines keeps it in such constant motion that the actual distance it travels is even longer than one would suppose from the extent of the digestive system.

The Liver. — The human **liver** looks very much like that of an ox. It is dark red in color and weighs several pounds; it is located at the right of the stomach and a little above it (see Figure 18). As it is one of the largest organs in the body, we might conclude that it has some important work to do. One thing that it does is to produce a liquid called **bile** or **gall**, which flows into the intestine when food enters it. This liquid helps the intestines in their work, especially in digesting fats. The assistance rendered the intestines is not, however, of sufficient importance to account for the fact that the liver produces a pint or more of bile every day. It appears to be largely waste matter that is taken out of the blood by the liver, and is poured into the small intestine so that it may be removed from the body, with the waste products of digestion.

When, for any reason, the action of the liver is impaired, the skin grows yellow and illness may result; the person is said to be **bilious**, and in severe cases is said to have **jaundice**. The trouble in these cases seems to be that the bile, instead of being freely discharged into the intestine, is held back and absorbed by the blood.

The Pancreas. — Just below the stomach is a long, thin gland, called the **pancreas** (see Figure 18). It produces a liquid called the **pancreatic fluid**, which passes into the intestines. The food from the stomach is mixed with the bile from the liver and the fluid from the pancreas almost as soon as it enters the intestines. Of all the digestive juices this is the most important. By itself it can digest all kinds of food, and it completes what the other digestive juices have not been able to finish. There have been cases in which it was found necessary to remove the stomach completely, so that the food passed directly from the gullet into the intestine. The pancreatic juice was then found to be sufficiently powerful to do the entire work of digestion.

The Enzymes. — All the digestive juices — saliva, gastric juice, pancreatic juice — contain powerful substances called **enzymes.** Saliva has one enzyme; there are two, of a different kind, in gastric juice; and several, still different, in the pancreatic juice. The *quantity* of enzyme in a quart of any one of these juices is small (much less than 1 per cent), but it is by the enzymes that the food is actually digested.

Foods Are Changed in the Intestine. — When the food mass reaches the intestine there is much starch in it, for all the starch that was not converted into sugar by the action of the saliva is still unchanged. One of the enzymes in the pancreatic juice turns this starch into sugar which, after being dissolved in the liquids present in the intestine, is ready to be absorbed into the blood. *Cane sugar* is also transformed, by another enzyme of the pancreatic juice, into a more simple form of sugar which

can be used by the body. The *proteids* that were not fully digested by the stomach are quickly acted upon by a third enzyme in the pancreatic juice. The drops of fat, which in the stomach were only freed from their coverings, are here digested by the combined action of the bile and a fourth enzyme in the pancreatic juice, and are dissolved in the liquids in the intestine.

The process of digestion in the small intestine takes from two to four hours; and while it is going on, the inner walls of the intestine are in motion, squeezing the food, and mixing it with the digestive juices so that it may become dissolved. Finally, when the process is completed, the food is in liquid form and is ready to be taken up by the blood and sent over the body.

The Large Intestine. — The portions of the food that remain undigested pass from the small intestine into the large intestine, together with the bile and some other materials. Some absorption of water takes place there, but there is little further digestion, most of the contents of the large intestine passing out of the body as waste. There are certain vegetables and fruits which consist largely of material that is not digestible; yet they are useful to us because of the juices they contain, and because of the bulky portion of them that remains undigested and, in passing out of the system, bears with it other wastes.

Waste Materials. — It is most important that the waste materials should pass away from the body every day, for if they remain in the intestine they make trouble. This waste may putrefy even in the intestine, forming poisons which are injurious to the body. With a little

care, it is easy to form the habit of expelling the waste at a regular time every day; the body likes regularity and will readily açquire such habits. In case the bowels become sluggish, exercise in the open air, eating fruit, and choosing coarse food will help the body to get adjusted. The regular use of drugs to move the bowels is a great mistake.

Indigestion. — What we call "indigestion" may show itself in a pain in the stomach or bowels, in nausea, or in diarrhea. It means that some one of the digestive processes has been seriously interfered with; perhaps we have eaten some spoiled food, or food that is not suited to us; or we may be eating too much, or too rapidly. The best way to relieve indigestion is to remove the cause, by correcting our wrong habits.

How Food Is Absorbed

The processes of digestion here described have gone on from six to eight hours, but as yet the body has not made use of the food on which the digestive organs have been so busily at work. The fact is that little of it can be used within six hours after eating; and much of it may not be used the day we eat it. None of it can feed the body until it is **absorbed**, that is, until it is taken into the blood. There is a little absorption from the stomach, and some from the large intestine; but any one who had to live upon what is absorbed by those two organs would soon starve to death, no matter how much food he ate. In the small intestine there is a wonderful arrangement by which the digested food is delivered to

the blood. As soon as this transfer is made, the food can be carried by the blood everywhere through the body.

The Villi of the Intestine. — How does the food get out of the small intestine and into the blood? One might think it would be emptied into the blood, as the contents of the stomach are emptied into the small intestine, but a much better and safer way is provided.

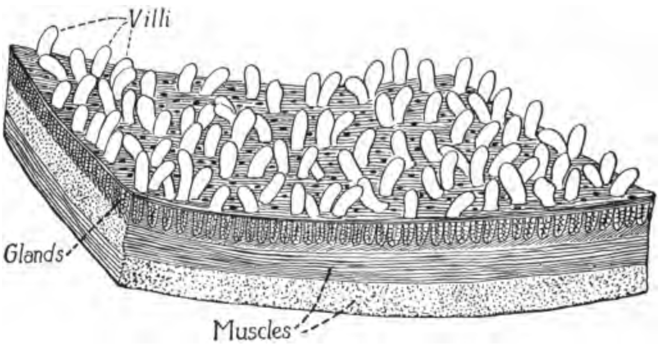


FIG. 19. — THE VILLI.
A small piece of the intestine highly magnified and showing the villi.

The inner surface of the small intestine is covered with tiny projections which, like little fingers, extend into the intestinal tube. They are so small that they can just barely be seen with the naked eye. There are millions of them; and they give the inside of the intestine a soft, velvety surface. They are named **villi**. It is their duty to take the liquefied food out of the intestine and to pass it on to the blood. As soon as the partly digested food enters the intestine, it comes into contact with these tiny villi; it is tumbled around over them, by the motions

of the intestinal wall, all the time that it remains in the intestine.

The villi are able to make their selections from the food materials that surround them. They will not take up waste matter or food that is not properly digested. An experiment like that represented in Figure 20 illustrates how they do this. Take a short piece of sausage skin (which really comes from the walls of the intestine of some animal), fill it with a strong solution of sugar, and suspend it in a small dish. After half an hour or more, taste the water in the dish; it will be found to be sweet. Some of the sugar has passed out through the wall of the sausage skin into the dish of water. In much the same way sugars and other foods pass from the intestines into the villi.

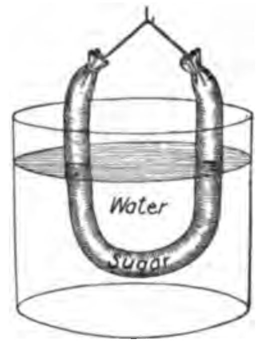


FIG. 20. — A DIAGRAM SHOWING THE ABSORPTION OF FOOD.

Small as the villi are, each one has many tiny blood vessels inside it. Some of these blood vessels soak up the sugars and digested proteids taken by the villus, while the fats do not go into the blood vessels at all — which shows that the villi know how to separate the food they take in. The fat which is absorbed passes into a tube in the middle of the villus; that tube is printed in black in the colored illustration, page 102. From the villus the two varieties of absorbed food are carried in different directions. The sugars and digested proteids, which have been taken into the blood circulating in the villus, are carried in the blood to the liver,

where, as we shall presently see, they leave part of the sugar.

The tube in each villus which receives the fat unites with thousands of others from other villi, forming tiny vessels which are called **lacteals** (milk holders), so called because the fat inside them looks at this time white like milk. These lacteals finally all unite into one rather large vessel that passes up through the chest and empties into one of the large blood vessels in the neck. Thus all the fat is poured into the blood near the heart.

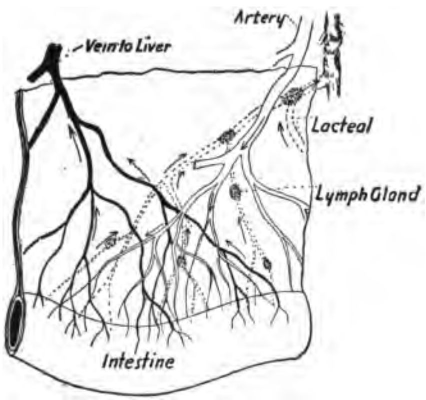


Fig. 21.—A Bit of the Intestine, with Vessels Connected with It.

The figure shows arteries, veins, and also the lacteals that take away the fatty food.

The Body's Storehouse. — Every working part of the body needs a constant supply of food. After a meal a large amount of liquid food from the intestines is poured into the blood, then it may be hours before any more is received. If all this food should immediately pass to the working organs, they would have an oversupply for the time being, and then a great scarcity until the next meal was digested. Such irregularity in the supply of food (and hence of energy) would interfere with the work of the body. To prevent this, the food, as soon as it is absorbed by the blood, is carried to the liver, where

much of the sugar is taken out of the blood and stored for future use. Then later, when the active organs demand food, the liver gives up its store to the blood. Thus the blood contains about the same amount of food at all times. If there is more sugar in the blood than the liver can take care of, the liver is likely to get out of order and the person will feel " out of sorts." The best remedy is to eat less sugar and to take more exercise in the open air, for exercise uses up the excess of sugar.

QUESTIONS

1. What change has taken place in the food between the time when it enters the stomach and the time when it passes into the intestines?
2. What work remains to be done?
3. How long is the large intestine? The small intestine?
4. How can tubes of this length be contained in the comparatively small space which they occupy?
5. What is bile? What is its use?
6. What can you say of the importance of the pancreatic juice? Is it more or less important than the gastric juice?
7. What are the enzymes? What fluids contain them? What is their use?
8. Describe the process of digestion in the small intestine.
9. What happens to food if it is kept too long either in the pantry or in the intestine?
10. What can we do to help the body if it does not expel wastes regularly?
11. What is the purpose of digesting food?
12. Describe how the digested food gets into the blood.
13. Trace the journey of a piece of fat meat from the time it is swallowed till the end of its journey.
14. What can you say of the importance of the liver?
15. Why does a brisk walk or a horseback ride often cure one of feeling "out of sorts"?

CHAPTER X

HOW THE BODY SHOULD BE FED

What Shall We Eat?

The Choice of Food. — The different kinds of food have been considered and also the process by which they are digested and absorbed. We are now ready to take up the questions we all have been asking ourselves, How can I improve my choice of food and my habits in eating?

To let taste control the selection of food is foolish, unless we are prepared to educate our taste so that we shall enjoy all wholesome foods. There is no sensible reason for objecting to drinking a glass of milk, or to eating a dish of oatmeal; we can learn to enjoy both if we will. It would not be far from the truth if we were to regard every wholesome, digestible dish that we have not learned to eat as one count against us. In choosing our food there are a few actual requirements to be considered.

1. We must have some proteids, and we can get them from meat, eggs, cheese, beans, bread, and many other foods.

2. We must have some fuel foods, and these we can get best from the grains, from some vegetables, and from different forms of fat.

Digestibility of Foods. — Some persons see better than others can; it is equally true that some digest food

better than others can. Everybody ought to know which kinds of food are most readily digested. One who has a good digestion need not avoid foods that are hard to digest but should use them carefully, not taking too much of such food at one meal. One whose digestion is not so good shows his common sense in living principally on food that is easily taken care of by the digestive organs; in that way he may often greatly improve his digestion and so be able, later, to eat more liberally with entire safety.

Cheese, for example, contains a very large amount of valuable food, but it is harder to digest than meat, and is therefore less useful. If cheese is eaten in small quantities, and with other food, it does not usually trouble people who have good digestions. If eaten in large quantities or without other food, the digestive organs have difficulty in disposing of it because it is so condensed. Beans are very nutritious; people in good health can eat them in moderate quantities; those who are not strong and those who lead an inactive life often have difficulty in digesting them.

Circumstances must also be taken into account. No one can derive the usual amount of nourishment from food that is eaten when he is very tired, or unhappy, or even when he is too busy to pay attention to what he is eating. When such times come, the sensible person will select food that is easily digested. Those who are living or working out of doors can eat food that might disagree with them if they were leading an inactive life indoors.

The following table shows some of the more easily digested foods and some of those less easily digested:

Foods Easy to Digest	Foods Difficult to Digest
Milk	All fried foods
Bread	Beans and peas
Rice and other cereals	Hard-boiled eggs
Soft-boiled eggs	Pork
Boiled beef	Veal
Fish	Cheese
Mutton	Nuts
Boiled chicken	
Broiled meats	
Potatoes	
Butter	

Methods of Cooking Affect Digestibility. — Foods that are boiled or broiled are, in general, more quickly digested than those that are *roasted*, because boiling softens the solids, and then the digestive fluids readily act upon them. *Fried* foods are the most difficult to digest,

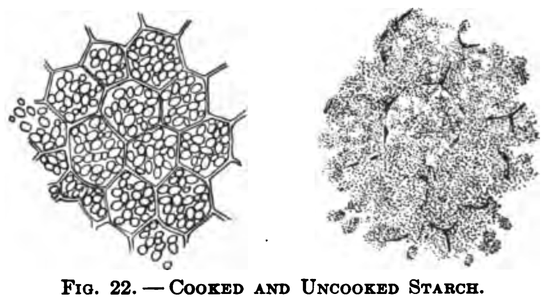


Fig. 22. — Cooked and Uncooked Starch.

The figure on the left shows about fifteen cells filled with starch grains; and that on the right shows about six of the cells after cooking.

since the frying is apt to soak the food with fat, which makes it difficult for the digestive juices to act upon it. There are a few vegetables, like lettuce and celery, that

we eat raw. Most vegetables are not digestible until they are cooked, because they contain starch in the form of hard grains, upon which the digestive juices do not easily act. Cooking swells these grains and makes them soft and easy to digest (see Figure 22).

How Much Shall We Eat?

Difficulty of Prescribing a Daily Ration. — It is admitted that most Americans eat altogether too much food. Many of the ailments from which they suffer can be relieved by giving them only two-thirds as much food as they are accustomed to eat and increasing the amount of time that they spend in the open air. It would be impossible, however, to say that certain classes of people ought to eat every day so many ounces of this kind of food and so many ounces of another. We know that what counts is not the number of ounces put into the stomach, but the amount of digested food that the blood can absorb from what is eaten; that varies with different people. Yet there are certain general directions that can be given, and by following them one may expect to discover for himself how to know when he is eating the right quantity of food.

How Food Needs Are Determined. — Experiments prove that a person who is doing even a moderate amount of muscular work needs twice as much food as the person who is studying or leading a quiet life. Brain work may seem to be as hard or harder than physical work, but it does not require extra food. Students should remember this, particularly when they are not taking much outdoor exercise. An aged person needs much less

food than one who is young. The young need plenty of proteid foods; and those who are working all day with their muscles need such foods as beans, cheese, graham bread, and fats, like salt pork. These will give them energy for their work.

Many interesting facts concerning the action of our bodies have been learned by inclosing a man in a large, perfectly air-tight, sealed box that was provided with arrangements for furnishing him with all the necessary oxygen, food, and water. The amount of food actually used up by the man's body can, under those circumstances, be accurately determined. It is found that the amount of food he uses depends upon how active he is. When he goes to sleep, the amount of food he uses decreases greatly, but increases again as soon as he wakes. A famous bicycle racer was once placed in such a box and asked to ride upon a bicycle, which was fastened inside the box in such a way that he could keep turning its wheels although it would not move along the floor. When he was trying to make this bicycle go as rapidly as if he were riding a race, it was found that he used up the food in his body about six times as fast as when he was remaining quiet.

In other experiments college students were put in the box and were given a hard examination paper to write. Although they thought they had worked very hard, the test showed that they had not been using any more food than they used when sitting still. Muscle work requires much food; brain work does not. So you can never tell a person exactly how much food he needs to eat since that differs so much with different conditions in his life.

The Average Daily Need. — In selecting food necessary to give us energy for our work, we cannot judge by bulk alone; a pound of bread will give much more strength than a pound of oysters, and it will cost much less than the oysters. It is important to know from

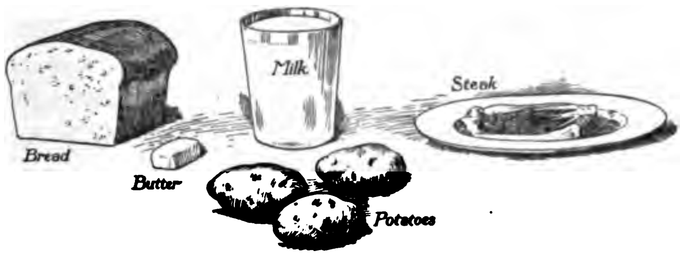


FIG. 23. — A DAY'S RATION.

This figure shows the amount of food required in twenty-four hours by a full-grown man. Bread, one-half a five-cent loaf. Steak, one-half a pound.

which foods we derive the most real nourishment. Study the table on page 87.

An idea as to the amount of building food and fuel food needed in a day may be gained from Figure 23. It represents a day's ration, i.e. the amount needed by an ordinary man in twenty-four hours; a child would require about two-thirds as much. Vegetables and fruits could also be added to such a ration to advantage, especially those that contain little nourishment but are useful chiefly because of their juices.

Variety in Food. — It is a mistake to have many different kinds of food at one meal; the variety of flavors and the pleasurable taste of one dish after another, often lead us to eat much more than we either need or want.

Variety in food is desirable, but that can easily be secured by varying the food from day to day. A heavy dinner, with several meat courses and highly spiced entrées, is not nearly so wholesome (nor so pleasurable) as a simple dinner consisting of meat or cheese, potatoes, a single vegetable, bread and butter (with milk for the children), and fresh fruit or a simple pudding.

The food eaten by families with small incomes is usually more wholesome than that of those who have plenty of money to spend. The latter are likely to make expensive meats the principal part of each day's diet, and that is certainly unhealthful. It is a real misfortune to be able to buy such foods and not to know better than to use them. Those who are obliged to choose inexpensive food, and to consider how they can get the most nourishment at the lowest cost, generally select such foods as bread, beans, milk, rice, and potatoes; these are not only inexpensive but are also the most desirable foods for constant use.

Candy as a Temptation to Overeating. — Sugar is a good food, yet those who like candy are constantly being warned that it is unhealthful to eat much of it. This seems contradictory, but there are good reasons for the warning.

1. Candy is made of cane sugar, the most difficult sugar to digest.

2. Sugar is a fuel food of much value to an active person who is using up a great deal of energy; but if eaten in any quantity by a person who is not active, it makes him fat and sluggish.

3. We usually eat candy, not because we are hungry

but because we like it. The result is that when we have eaten enough to give us all the fuel food we need, we have seldom satisfied our taste, so we keep on eating candy and thus create an oversupply of this kind of food.

4. We are apt to eat the candy between meals or after eating all the food we need in some other form.

When Shall We Eat?

Regularity of Meals. — It makes little difference about the hours selected for our meals; but it is of great importance that meals should be at *regular hours.* There are many different kinds of work going on in the body, all related to one another to a greater or less extent, and the work of the body will be carried out better if all kinds of work are harmonized. The first requisite is that meals should be at the same time every day. In this country most persons eat three meals a day; in other countries five meals are common; in some two meals are the rule. The body will adjust itself perfectly to any of these plans, if people recognize that they need a certain amount of food each day and eat only that amount, whether they take it in two meals or in five.

This does not mean that it is well to eat three regular meals, and then candy or other food between meals, morning and afternoon. The stomach depends, as much as you do, upon having regular times for work and for rest. Think how difficult it would be if when you went to school in the morning you never knew whether, when it was time to close for the day, the teacher might not announce that there would be an extra session of three or four hours. That is the way we treat the stomach

when we eat "between meals." Even if we only eat one slice of bread with butter, the digestive processes have to take place just the same as if we had made a whole meal of bread and butter. A lunch during school hours may be useful for those children who for any reason have an insufficient breakfast, but it is not to be recommended for those who eat a good breakfast.

A Suggestion for Each Meal. — Most people eat *breakfast* shortly after rising; it should not be a hearty meal. Fruit, a cereal, and bread and butter make a good breakfast for those who are not doing hard muscular work; those who are working out of doors may want to add an egg. Milk, cocoa, or chocolate may be used, but we must then remember that they are all foods; and if we take them, we need less of other food. Water is the best drink for young people; they should not drink coffee, although most adults can drink it without injury if they do not use too much.

The *hearty meal* should be in the middle of the day or at the end of the day — preferably at the time when a person can either rest directly after eating, or else do only light work. It is not well to do hard muscular work for half an hour after a hearty meal, for that work will call to the active muscles blood that is needed by the digestive organs, and so will interfere with rapid digestion. Mental work interferes less; but the meal interferes with the mental work, for everybody knows that it is difficult to study hard right after dinner. The stomach takes the blood that would otherwise be used by the brain, and the brain cannot work as well. So the rule is no heavy work, muscular or mental, directly after

dinner. Do athletes ever eat just before going into a race?

The *third meal* of the day should be a simple one, whether it comes at noon or at night. Bread and butter, or macaroni, or rice, make the best foundation for this meal, with an egg if one is not taken at breakfast, and some stewed fruit or a custard. It is not well to form the habit of taking a bedtime lunch; healthy people are much better off without it. For habitual wakefulness, a glass of hot milk on retiring is an excellent remedy.

How Shall We Eat?

1. Eat slowly and be sure that the food is well chewed before it is swallowed.

2. Do not eat between meals; that is a severe tax on the stomach, as it keeps the glands in constant action.

3. Do not eat a hearty meal when either very warm or very tired. Rest a little first.

4. Do no hard physical work for at least half an hour after a hearty meal. This is the stomach's busiest time. We should help it by keeping the body quiet.

5. Remember that the person who lives a very active life can best digest and absorb his food. If you live a quiet life, you need less food than if you were doing hard physical work.

6. Drink plenty of water. Water is required to dissolve the food in the intestine. It is also required to keep the blood in proper condition. We are much more likely to drink too little water than too much. A person needs in all about nine glasses of water every day; the

food he eats might contain from three to five glasses. If we are really careful to masticate our food, and to drink slowly, we shall never drink too much water, even if we drink freely during a meal. Ice water, if used at all, should be sipped *slowly,* so that as it passes down the throat it may be warmed. Ice water in large quantities produces a shock when it enters the stomach and may interfere with digestion.

It used to be thought, before digestion had been studied in the great scientific laboratories, that it was well for people to take wine or some other alcoholic drink with meals, to aid digestion. Now it has been demonstrated that this was wholly a mistake; that no healthy person should use alcohol for that purpose; that it does not help him to digest his food. Those who wish to be strong and vigorous, with healthy digestive organs, had better let alcoholic drinks entirely alone. When people are ill, it is for the physician to direct what they should do.

QUESTIONS

1. Why should we educate our taste so as to enjoy all kinds of wholesome foods?
2. Why should we avoid eating large amounts of foods that are difficult to digest?
3. Since cheese is made from milk why is it not as good a food for babies?
4. What kind of employment can you think of that would require a large amount of food? What kind that would need little food?
5. Can you think of any reason why a child may need almost as much food as a man?
6. Can you give any reason why wealthy people are more likely to suffer from indigestion than people in moderate circumstances?

7. How much time do you usually spend in eating your breakfast? Is this enough?

8. What is the objection to eating between meals? Can you give any reason why a school lunch is frequently allowed?

9. Can you give any reason why the hearty meal should be for most people at the close of the day? Why not just before going to bed? Why should not breakfast be the hearty meal?

10. Have you ever suffered with bad dreams after eating a very hearty supper?

11. Why should one avoid talking about unpleasant subjects while at the table?

12. Why is it difficult to study just after dinner?

13. What are your favorite dishes? Have you ever eaten too much of any one of them?

14. How much water should one drink during the day?

15. Give reasons why you should not eat your lunch and study at the same time.

16. Why should candy be eaten in small amounts?

17. Read over the rules for eating and write down what ones you follow and what ones you do not follow.

CHAPTER XI

INTELLIGENT COOKING

Importance of Good Cooking. — Most of the food we eat is cooked. Cooking may either spoil food or greatly improve it; good cooking enables people to get full value from the food they eat. There are many ways of cooking, and since the meals for a family are usually prepared by one person, it is not necessary for each member of the family to know how to make all kinds of dishes. The principles of cooking every intelligent person ought to understand. Further than that, every boy should know how to cook well the simple foods that are prepared when camping or living out of doors. Every ambitious girl, no matter what her circumstances in life may be, ought to learn how to do, and do *well,* all kinds of plain cooking. Even though she may think she will never need to do cooking in her own home, she must appreciate that she can manage a household to better advantage if she knows how to buy food and how to care for it, how it should be cooked and how it should be served. Could a man manage his business properly if he were ignorant of all its details? Yet many women try to become good housekeepers without knowing thoroughly the details of each branch of work that is done in their households.

Why We Cook Food. — There are three reasons for cooking food.

1. Cooking *removes the danger from parasites;* this applies particularly to meats.

2. Cooking *develops the flavor* of foods, which means that we enjoy eating them more, and so digest them better.

3. Cooking *makes most food easier to digest;* this is especially true of all starchy foods.

In general, food is cooked in order to improve it; so one of the first problems in cooking is to learn how to apply heat to different kinds of food in the way that shall improve them most. Fats are melted or made softer when heated. Heat swells the grains of starch and causes them to soften, so that they are more easily digested (see Figure 22). It has an opposite effect on meat and eggs; they are hardened by heat, as are most other proteids, and they are therefore more difficult to digest after cooking. The reason for cooking them is because most people enjoy their flavor better after they are cooked. With meat there is an additional reason; raw meat is less safe than cooked meat because of the parasites that may be in it. With proteids, therefore, one problem is to cook them in such ways that the heat used shall not harden them too much.

Three Different Ways of Cooking. — In a cookbook there are hundreds of recipes for *preparing* food. When it is ready for cooking, there are only three ways in which the cooking is done: *boiling, baking, frying.* Potatoes may be cooked in any one of these ways, and the use of different methods at different times gives the needed variety. In cooking proteid food, we have to consider more than how to secure variety. Sometimes we want to keep the rich, nutritious part of the meat inside of it;

sometimes we want to let the nutriment out into the liquids in which the meat is being cooked. We have to proceed differently in the two cases.

To keep the richness in the meat itself, we apply a considerable degree of heat to the outside of the piece of meat, heating it quickly so that the surface will be seared, forming a crust that will hold the juices within. To draw the richness out of the meat and into the juice, we heat it very, very slowly, allowing no crust to form.

Baking. — Cooking food in hot air, we call **baking**, **roasting**, or **broiling**, depending upon the manner in which the hot air is applied. If it is desired, as with meat, to form a crust quickly, then the food should be put into a hot oven, and the heat gradually decreased. Some of the flavor and richness of the meat will escape through the crust, but much of this can be preserved by basting the meat every fifteen minutes; that is, pouring over it the liquids that have escaped into the baking pan. When there is no occasion to form a crust, even heat is the best, with extra heat at the end if it is desired to brown the top of the dish.

Broiling means cooking over a very hot fire. It is really a form of baking. We usually speak of broiling meat; the toasting of bread is also a form of broiling. When broiling meat, it is important to prepare in advance a hot bed of coals (or in a gas range, a well-heated broiler), so that the outside of the meat may be quickly seared over and the juices kept in it, instead of escaping on to the coals.

Boiling. — When food is cooked in boiling water, we call the process **boiling**. If the goodness is to be kept

within the food, we put it into water that is actually boiling. To extract the goodness, we put the food into cold water, and let the water come to a boil so gradually that the strength of the food has a chance to soak out before the boiling begins. If the liquid in which your mutton was boiled tastes rich enough to make good soup, then there was a mistake in the beginning, — too much of the flavor of the meat was allowed to escape into the liquid. Vegetables, too, should be dropped into boiling water, so that the flavors may not be soaked out of them in the process of cooking and be lost when the water in which they were boiled is thrown away.

In making a soup, we usually desire to extract the flavor from the meat and the vegetables. So both meat and vegetables should be cut up into small pieces and put into the soup kettle with cold water. The kettle is set back on the stove and is gradually heated; if it simmers for hours, without boiling, the flavor of the soup will be better. Even with all this care, much of the value of the meat remains in the meat itself. For that reason clear soups, from which the meat has been strained, have little food value; they are regarded as good "appetizers" with which to begin a dinner.

In stews, the meat and the vegetables are served with the broth; then we get the whole goodness of them — the flavors in the broth and in the meat, and the proteids which were coagulated by the heat and would not soak out into the broth. Stews are therefore very nutritious.

Frying. — We fry foods by dropping them into fat which has been heated very hot. Foods cooked in this

way are coated with a hard, fat-soaked crust which renders them difficult of digestion.

Beef Tea. — Often it is desired to extract the nourishment from a piece of beef for an invalid who is not able to eat the meat, no matter how carefully it may be cooked. A common method is to make beef tea; it has a delicious odor and taste, but if made in the ordinary way it has little to recommend it except its flavor. When the beef is cut into very small pieces and put to soak in *cold* water, a part of the nutritious proteid material will be extracted; but if the liquid is allowed to come to a boil, the proteid will at once coagulate and appear in a brownish skum. When we strain that off, we remove almost all the nutriment the liquid contains. If the liquid were only slightly warmed so as not to coagulate the proteid, it would still contain nutriment; but if it is boiled and strained, no real food is left in it.

"**Raising.**" — Meat and vegetables require little preparation previous to cooking, and the same is true of the grains when used as cereals. But it is different with the making of bread, muffins, cake, pies, and the many other foods of that general sort. Flour is seldom used without some form of "raising" material to make the batter "light," yeast or baking powder being generally used.

When bread is made, yeast is added to the dough and the mixture is put into a warm place to "rise" for several hours; that is, to allow the yeast plants to grow in the mixture. As they grow they produce a gas called carbon dioxid and a very small amount of alcohol; the bubbles of the gas make the mixture swell as they try to escape from it. The "raising" must be stopped at the right

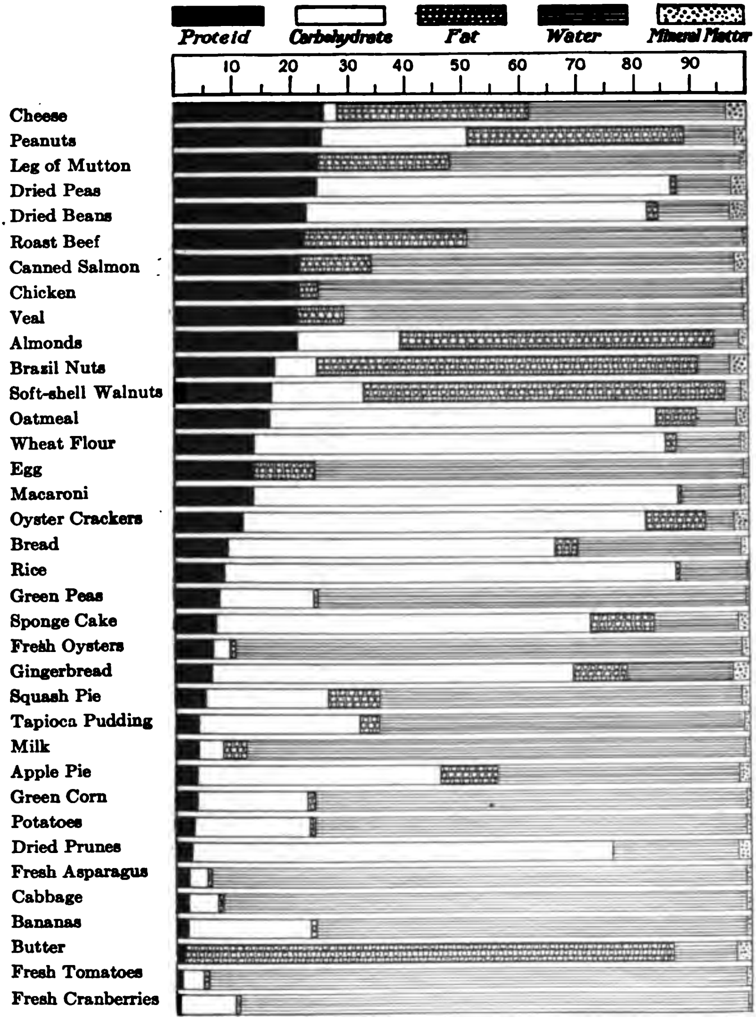


FIG. 24. — A table showing percentages of different food substances present in ordinary foods, arranged according to the amount of proteid they contain.

time or else the mixture will sour. It is stopped by putting the loaves into the oven, the heat then killing the yeast and driving off both alcohol and gas. No trace of the alcohol is left; but the gas leaves its traces in the small holes all through the loaf which were full of gas when the loaf went into the oven. Their presence makes the bread "light," easier to masticate and to digest.

Baking powder acts in much the same way as yeast; it is a more expensive method of raising dough, but it works immediately. So it is often more convenient to use baking powder, and less skill is required for its use. The flavor of food raised by baking powder is quite different from that of food raised by yeast.

QUESTIONS

1. Give three reasons for cooking food. Which of these reasons applies most to the cooking of potatoes? Meats? Eggs?
2. Why is it important that every one understand the principles of cooking?
3. What advantage is there in having food well flavored?
4. Why should one give careful attention to the temperature of the oven before putting meat in to roast?
5. Which will keep the more food value in a piece of meat — baking or boiling? Why?
6. Why is beef stew an especially nutritious dish? Find out the average cost of meat suitable for a stew. Compare this with the cost of porterhouse steak or mutton chop.
7. Why is it that beef tea, although it is made of meat, has practically no value as a food?
8. What objection is there to frying food?
9. How many ways do you know of cooking eggs? Which do you think makes them most digestible?
10. What kind of bread do you think could be made if neither yeast nor baking powder were put in the dough?

CHAPTER XII

INTELLIGENT FIGHTING OF THE BODY'S FOES

The Body Its Own Hospital. — The body has to contend constantly with our carelessness; we eat the wrong food or we eat at the wrong time, and get sick stomachs. Then accidents happen which we could not prevent — a bone is broken by a fall, or some part is wounded, or we "catch cold." The body, if properly cared for, is able to deal with all these difficulties; slight illnesses are soon righted, broken bones are mended, and even deep wounds heal in a short time. In fact the most wonderful hospital in the world is the one that the body itself conducts; small disorders are set right in the body without our ever being conscious of them at all; ordinary illnesses are cured without even making it necessary for us to stay in bed.

Drugs Do not Cure Disease. — When the disorder is one that is not quickly righted, we say that the person is ill, or has some **disease.** If the illness is serious, a doctor is summoned; if it does not seem serious, many people begin to take some medicine which their friends may recommend to "cure" the illness. But medicines do not *cure* diseases; at best they can only help the body to right itself. Under ordinary circumstances, the best way to help the body is to find out what wrong habit or what carelessness is causing the trouble — and stop it.

A few simple remedies like hot baths, change of food, extra exercise in the open air, and other things that will be mentioned in this book are much better aids to the body than drugs. If medicines are needed, they should be taken under the direction of a physician. What does a physician do when he is sick himself? He does not begin taking drugs; he sends for another doctor, tells him about the illness, and takes such medicine as the doctor prescribes. He knows that a sick person is not a good judge of what he needs.

The Patent Medicine Folly. — It is estimated that over $50,000,000 are spent in this country every year for "patent medicines"; that is, for prepared drugs that people buy to "cure" some disease or other. This is a very expensive way of buying medicine; in many cases a "dollar bottle" contains only a few cents' worth of drugs. Many patent medicines may be harmless; but others are most injurious and their use is worse than foolish. If you find that the lamp on your table is going out, you do not run for matches and keep trying to relight it. You investigate to see whether the oil has burned out or whether the wick is too short to reach the oil; that is, you find the cause of the difficulty and remove it. One's body is worth as much care as a lamp; and it is much better to discover what is wrong with it than to run to the drug store with a dollar bill for some patent medicine that cannot "cure" the trouble, and may make it much worse.

The Body's Worst Enemies. — In our battle to keep well and strong there are certain diseases that we have to fight; to understand about them it is necessary to

know something of what has been discovered in the last fifty years about the worst enemies of the body. These are tiny animals and plants, many of them too small to be seen with the ordinary microscope; they get into our bodies and grow there, the result being that we are ill, perhaps very ill. When any living thing lives in and feeds upon another, we call it a **parasite**; and these plants and animals that cause disease are also parasites. Mention has been made of the Trichina and the tapeworm, parasites which may make trouble in the intestines; but more important than these are microscopic plants called **bacteria**.

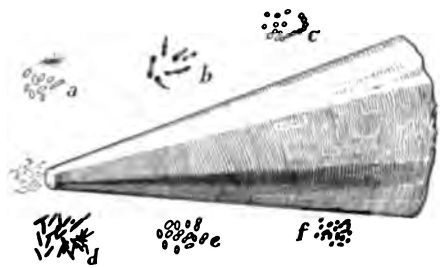


FIG. 25. — BACTERIA AND THE POINT OF A CAMBRIC NEEDLE.

The figure shows the comparative sizes. The minute dots at the end of the needle represent the size of the bacteria. The others arranged around the needle are bacteria more highly magnified. The sources of the latter are: *a*, typhoid fever; *b*, diphtheria; *c*, boils or abscesses; *d*, tuberculosis; *e*, sour milk; *f*, grip.

We have already found that bacteria may live in milk and also float about freely in the air, ready to fall into our food. Are they all enemies? Indeed they are not. Many bacteria are really our good friends and do much useful work for us. But other kinds of bacteria are our worst enemies; these are called **germs**, and the diseases they produce are called **germ diseases.**

Every germ disease is produced by a special germ which causes that disease and no other. Some of them are

dangerous only to the person whose body is attacked by the germ. But there are others that are likely to pass from the sick person to the well people around him, and we call the diseases they produce **contagious diseases.** When a child in the family has the germ disease called malaria, there is no more reason to fear that the other members of the family will take malaria from him than there is that they would break their arms if he broke his arms. Malaria is not contagious; but if a child has measles, the other children in the family would be likely to "catch" the disease from him. All diseases caused by germs are called **infectious**, but not all of them are **contagious.**

Until recent years, no one knew *how* certain diseases passed from one person to another; the result was that one sick person often gave a contagious disease to hundreds of others, without anybody's knowing how to prevent it. Now most contagious diseases can be checked before they spread through the community if every one will take the precautions that have been discovered to be necessary.

How the Body Is Protected. — Disease germs are mostly short lived. To be sure there are countless millions of them, but most disease germs live only a few weeks unless they can find entrance into the body of a human being or an animal and begin to grow there. Fortunately for us there are not many ways in which they can enter our bodies. The body is covered with skin, which to a little germ is thicker and firmer than a stone wall; unless there is some break in it (like a loose stone in a wall) the germs are barred out by one's skin. When the skin is

whole, about the only ways open to germs are to get in with the air we breathe, or with our food and drink.

When they once have found their way into the nose or the mouth, they can easily get into the stomach or the lungs. But even then it is more than likely that the body will be able to destroy them before they do any harm. A robust body has great power to resist the attack of disease germs, for it can frequently prevent their having any chance to grow even if they do find an entrance. So the first and best precaution against these tiny enemies is to keep in good physical condition; that we can do by eating plain wholesome food and following the other rules of health that most of us know but are too apt to forget.

Germ Diseases in the Digestive Organs

It is not important for people to know about the diseases that they cannot avoid taking. If such a disease comes, we send for the doctor and do whatever he tells us will help the body to fight against it. We are not studying diseases in this book — it is enough for doctors to know all about them. What we want to know is how to keep well and how to avoid those diseases that may be avoided.

There are three diseases of the digestive organs about which everybody should know, because they are common, serious, and preventable. One ought to understand both how to guard against having them, and how to prevent giving them to others if he chances to be taken with one of them himself. These three diseases could be completely stamped out if it were only possible to prevent,

for one year, the existence of a single case. Then we should probably never hear of them again, except as strange disorders that used to prevail before people took the trouble necessary to get rid of them. Those three diseases are typhoid fever, hookworm, cholera.

Typhoid Fever. — No one ever has **typhoid fever** unless a special kind of germ that causes it gets into the intestines, and is able to overcome there the resistance of the body (Figure 25). If the germ gets a start, it grows rapidly in the intestines and produces an immense number of germs like itself which work serious mischief. The germs pass from the body in the feces and in the urine; they are not dead, but are ready to do the same work in the body of some one else. They can remain alive for about six weeks; then, if they do not find their way into the body of another person, they die. Since there is no danger of taking them from the sick person's breath, one might imagine that it would not be difficult to take such care of the discharges from the patient as to protect other people. But the fact that we cannot see the germs makes it much more difficult to avoid contact with them. They are commonly carried to well people in four ways.

In Drinking Water. — How could excretions from a person sick with typhoid fever get into drinking water? Through carelessness on the part of those who take care of the sick person the excretions may be thrown on to the ground and from there washed into a well. A crack in the floor of a well house may be more dangerous to a community than a mad dog. When the excretions are put into water-closets, they pass from there into the sewers in the streets and through the sewers into some

stream of water. If the people who live a few miles further down the river take their drinking water from it, they are likely to keep having cases of typhoid fever. Any stream into which sewage is emptied is unsafe as a source of drinking water. There are three things that may be done: either find some other way of disposing of the sewage, or find some safe source from which the drinking water can be taken, or use some method of purifying the water. Until one of these safeguards has been put into operation the citizens should, for safety, boil all their drinking water, and thus kill any typhoid germs.

In Milk. — Typhoid germs are occasionally found in milk, and yet the disease germs do not come from the milk itself. If the milkman washes his cans in water that, without his knowing it, contains typhoid germs, they may get into the can and so into the milk. Sometimes they are communicated to milk from the handling of the milk receptacles by a milker who is recovering from the disease. Sometimes people who have recovered entirely from the disease, or may never have had it, carry the germs around in their bodies for a long time. They are called "typhoid carriers," and it is dangerous to have them work in a dairy. This may seem a fantastic account of the way typhoid fever is spread, but many instances are known in which one case, improperly cared for, has resulted in many others.

A typical instance occurred in a small city where some forty people were taken ill with this disease at about the same time. Several died, and for weeks the others were very seriously ill. It was found that all the sick people had been using milk from a certain dairy. An inspection

of this dairy disclosed the fact that about two weeks before the typhoid cases started a "typhoid carrier" had been employed in the dairy. Without knowing it, he had communicated typhoid germs to the milk he was handling, and those who drank the milk suffered.

By House Flies. — Flies always congregate in foul places; if they happen to feed on the feces of typhoid fever patients, the fever germs may adhere to their feet, and then they may carry those germs into the kitchens where food is being prepared, and leave them on the food that is soon to be eaten. Flies look harmless, but they are not. There ought to be a general movement all over the country to kill the flies.

In some places, the house fly is called the "typhoid fly," as a reminder of the danger from it. The best way to

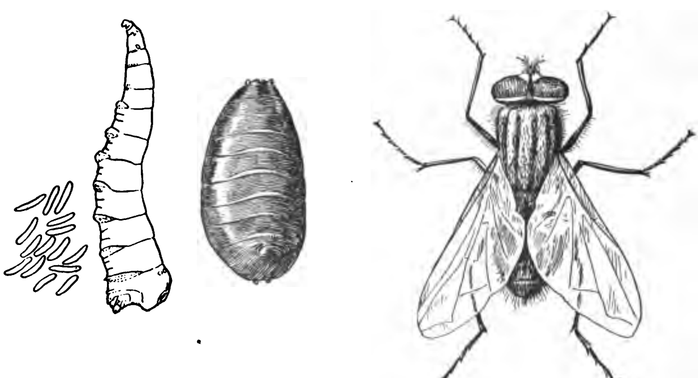


Fig. 26. — A House Fly.

The eggs, two stages of the young, and the adult are shown.

exterminate flies is to destroy their breeding places, at the same time killing those that get into the house.

Flies lay their eggs in garbage cans, manure heaps, or other decaying masses. Thousands of flies may thus come from a single garbage can, for flies multiply very rapidly. A single fly if it has plenty of garbage to breed in may produce 25,000,000 others in 30 days. By spending a few moments in keeping garbage cans tightly covered so that flies cannot get into them to lay their eggs we can do much more toward reducing the numbers of flies than we could by going around all day "swatting the fly." The fight against the fly is a fight for health. Filth and health never make good bedfellows.

By Oysters and Shellfish. — If oysters and clams grow in water near the outlet of sewers, they may become contaminated with the typhoid germs; when they are eaten raw, the living germs may be taken into the stomach. The danger is greatest in the fall months; in winter, raw oysters are seldom if ever infected. When oysters are cooked, there is no danger from them at any season.

Here is a well-authenticated instance of the danger from eating raw oysters. There was a typhoid fever case near the seashore, and the excretions were thrown into a sewer. The discharge from the sewer floated over to oysters that were in the water, not far from the sewer. Later these oysters were sold in a neighboring city, and one evening about a hundred college students ate some of these oysters. Forty students were taken with typhoid fever, four of them died, and the others recovered after being ill for many weeks.

Hookworm Disease. — There is a disease very common in certain parts of our country called the **hookworm disease.** It is widely prevalent in the southern states,

and uncommon in the north. It is a strange disease, for the patient frequently does not realize that he is ill. He feels weak and indolent, and perhaps he agrees with his friends when they call him lazy; but he is really sick. In many cases the disease is serious; it prevents the growth of children and makes them so stupid that they appear only half-witted. A man with hookworm is about as efficient as if his right hand were tied. It spoils the lives of many people. Fortunately men have learned how both to prevent and to cure it.

The cure of the disease must be left to the physician. But the prevention is simple. The disease is caused by tiny worms that live in the intestines, sometimes in great numbers. These tiny worms produce many eggs which pass out of the intestine in the feces and then develop into little worms, too small to be seen by the eye. When, through careless disposition of the feces, these worms get into the ground, they may remain alive there for a long time. Then if a person happens to walk over the ground barefooted, the worms may attach themselves to his feet and cling to them. They proceed to bore their way through his skin and finally make their way into the blood vessels. They are carried around the body in the blood and at last may enter the intestine, where they soon give rise to the disease. Perhaps there are some other methods by which they may be communicated to the body, but this seems to be the most important.

It will thus be seen that the disease is spread by filthy habits; is acquired by going barefooted; and may be largely avoided by wearing shoes. An active campaign

carried out in the states that are most affected has largely reduced the disease.

HEALTH NOTES

Disease germs that are dangerous to human beings are more likely to be found in excretions from the human body than in any other substance. For this reason there is the greatest need that proper disposition should be made of the excretions. We have learned that typhoid bacteria and the eggs of the hookworm may be in the feces, and the germs of tuberculosis, as well as other dangerous germs, are also sure to be in these and other excretions. Hence great care is necessary not only in disposing of sewage but to make certain that toilets do not become a source of infection. Where toilets have connections with sewers they should be flushed with water every time that they are used, and the greatest care should be taken to keep the bowls of them absolutely clean.

Where the old-fashioned privy is in use, it must be so covered that flies cannot reach the excretions, for they not only find this their favorite place for laying their eggs, but they feed upon the filth, and then fly into the house, where they may light on food or on baby's milk bottle, leaving dangerous disease germs that have become entangled in the hairs on their feet.

QUESTIONS

1. Why should one avoid taking medicine except under the direction of a physician?
2. Have you ever noticed "patent medicine" advertisements in the newspapers? Can these medicines cure the diseases which they claim to?
3. Find out if you can some of the harmful ingredients which are occasionally found in patent medicines — headache tablets, catarrh cures, etc.
4. What are parasites? Are all disease germs parasites?
5. Can you explain why a cut or bruise should be washed with clean water?

6. What precautions can one take to avoid typhoid fever?

7. What is the best way of caring for garbage in the country? In the city? How should the garbage can be cared for?

8. Can you think of any reasons why it is the duty of every one to help keep the streets clean?

9. What dangers are apt to result if one allows the soil around one's house to become filled with pollution? Should there be a law preventing this?

10. Are there any places near your home which seem to be good breeding places for flies? Can you think of any ways in which these conditions might be avoided?

11. Why is it that barefooted people are apt to contract the hookworm disease? Where is this disease most common?

12. Describe some country farmhouse with which you are familiar where conditions of perfect cleanliness exist and tell what measures have been taken to make all the premises thus clean and sanitary.

13. Can you think of any reason why health officers do not give attention to indigestion while they do to measles?

14. Why is it that fewer soldiers in our armies die of disease than they did twenty-five years ago? Why cannot a city be just as well guarded as an army can?

SECTION II

WHAT THE BODY DOES WITH ITS FOOD

CHAPTER I

HOW THE BLOOD CARRIES THE FOOD

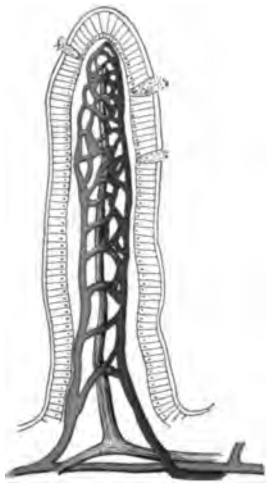
EVERY minute many parts of our bodies are working and are demanding food. The digestive organs take the food we eat and change it until it is in condition to nourish the body; their work is done when the prepared food is taken up by the blood. Then it remains for the blood to carry the liquid food where it is needed, to all parts of the body.

What the Blood Contains. — The blood contains a great deal more than the food which the digestive organs prepare for it. About one-thirteenth of a person's weight is the weight of his blood; a person weighing 100 pounds has about four quarts of blood. There is nothing about a drop of blood, glistening and of a beautiful red color, that would suggest the marvels it contains. It is more than likely that science does not yet know all about them, though the microscope has discovered many wonders. First, the liquid part of blood, called **plasma**, is not red; it is almost colorless. Plasma is largely made up of water; it also contains the digested and dissolved food and certain other substances that have been taken from

the intestine. Floating in it are millions upon millions of tiny little bodies called **corpuscles.** Most of them are of a reddish hue; their presence in the plasma gives the blood its red color (see colored illustration).

Each corpuscle is alive and at work. There must be a great deal of work for them to do, because when we count them, we find more than 5,000,000 in a drop about the size of a large pinhead. The number of corpuscles at work in your entire body is greater than the whole number of people who have lived in the world from the earliest time until to-day. Besides the red corpuscles there are others which are transparent or bluish in color.

Red Corpuscles. — The **red corpuscles** are so small that a row of 3200 would be only an inch long. The picture facing this page was drawn as they appeared to the artist when looking at a tiny speck of blood under a microscope. They seemed to him like round discs, pinched in at the middle. Those who have had opportunity to watch them as they are circulating in the blood vessels say that there they look very much like tiny, shallow bowls. They are a pale red because they contain a red substance (called **hemoglobin**) that is greedy for oxygen, and always seizes as much of it as it can. The red corpuscles are, therefore, the oxygen carriers of the blood; they take oxygen to every part of the body, at the same time that the blood plasma carries food to every part. Thus the blood carries all over the body the two things that we found to be necessary for combustion — fuel-food and oxygen. The red corpuscles never go out into the air to get oxygen, and yet every minute or so they take on a fresh supply of it. The means by which oxygen is



A Villus

The arteries are represented in bright red, the veins in dark red, and lacteal in black.

Blood as It Appears under the Microscope

In this figure the red and white corpuscles and the blood plates are shown. The faint red color is a close approximation to the actual color of the corpuscles as they appear under the microscope.

brought to these millions upon millions of tiny workers will be explained in a later chapter.

White Corpuscles. — The corpuscles that are transparent and slightly bluish are called **white corpuscles.** There is one white corpuscle to about 700 red ones; how many white ones, then, in a drop the size of a pinhead? Although the white corpuscles are slightly larger than the red, they are still very tiny. They are somewhat spherical in shape, as shown in the illustration below. Their work is very different from that of the red corpuscles; it requires them to change their shape and for this reason the microscope shows them with a variety of forms. Like the Home Guard in an army, they protect our bodies from invaders; it is their business to be constantly watchful for any irritating substances or germ enemies that may find an entrance into the body, and to do their utmost to dispose of such enemies before they cause trouble or disease. Small as these corpuscles are, they are larger than most of the disease germs; their method of fighting is to try to capture their enemies. They dispose of a captured enemy by eating it (see Figure 27); i.e. taking it into their bodies and destroying it. Stories are told about the manner in which the white corpuscles sacrifice their lives for the protection of the body, and how when an invader comes they send out calls to

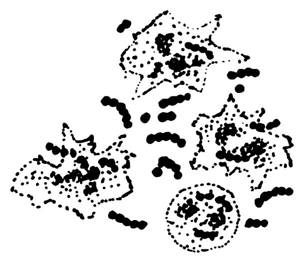


FIG. 27. — WHITE BLOOD CORPUSCLES.

This figure shows white blood corpuscles in the act of engulfing and destroying bacteria. The black spheres are bacteria.

each other for help at some particular spot. These stories are rather fanciful; the fact seems to be that these corpuscles are constantly going around the body, and when there is trouble at any spot, those passing that way stop to see what the matter is — much as policemen shoulder their way into a crowd if one begins to collect. In case the trouble is more serious than the passing corpuscles can handle, more blood is called to the spot, and in it come more white corpuscles.

Blood Plates. — There is a third kind of corpuscles in the blood, called **blood plates.** They appear to have nothing to do until the blood begins to flow from a cut or bruise; then they set to work to stop the loss of blood by helping to form a clot.

Discoveries about the Blood. — It has always been known that there is blood in all parts of the body, because wherever the body is cut it will bleed. But it was a long time before men discovered that the blood is actually pumped by the heart and flows around the body. It is difficult to realize that these facts, which can be given in so few words, represent the results of the investigations of many men who worked all their lives to find out what is now to us a commonplace. Probably no explorer who rejoiced over the discovery of a new continent or a new race of men, was ever more delighted at his success than were the two scientists who made the greatest discoveries about the blood.

Discovery of Blood Vessels. — The first one was a world-famous Greek physician, named Galen, who practiced medicine in Rome in the second half of the second century. He watched and experimented and

became convinced that there are two kinds of blood: bright red blood in a set of closed tubes called **arteries** and a purplish red blood in another set of closed tubes called **veins.**

Discovery of the Circulation. — For fourteen hundred years his theory was satisfactory to scientists; they found out much more than he had known about the arteries and veins, but it was not until the seventeenth century that the next great secret was discovered. Then an Englishman, William Harvey, found that the blood, instead of washing about like water in a pond, travels in a definite circuit, with the greatest regularity and precision, and is pumped along that circuit by the heart. When he announced this discovery Harvey was laughed at and abused; but he was right, and his name is everywhere associated with the great new fact, which he called the "circulation of the blood." How the blood passed from the arteries to the veins, Harvey did not know, for the tiny connecting blood vessels are so small that he never saw them.

An Outline of the Circulation. — It is not easy to describe the circulation of the blood, because the process, while perfectly simple in principle, becomes complex when represented. A brief outline of it may be of help at the beginning.

The heart pumps the pure blood into the set of tubes called arteries. These divide into smaller and smaller branches, like the branches of a tree, and one or more of the tiny branches goes to every part of the body; we might call those twigs. The ends of the smallest twigs again divide into very many still smaller ones, called

capillaries; these are altogether too small to be seen without a microscope. While the blood is flowing through the capillaries, it loses its bright red color. After passing through them it enters the set of tubes called veins, and in them is carried back to the heart. From the heart it is pumped to the lungs, where, by a process that will be described later, it is made bright and pure, after which it flows back to the heart — ready to start again on the route around the body.

The Network of Blood Vessels. — The blood goes on a distinct track, i.e. it goes only where the blood vessels go. But they go everywhere, for every single part, even a section as small as a pea, contains arteries, capillaries, and veins, forming side routes that branch off from the main lines. All the blood in the body goes through the heart hundreds of times a day. Not all the blood that leaves the heart at one time goes over the same route — just as all the passengers that leave a great railroad terminal do not go on the same lines or to the same destination. Some of them may go only a few miles, others to the furthest point on the longest line. Part of the blood that leaves the heart may travel in the arteries for only a few inches, then go into some capillaries, then into the veins, and then, in a very short time, back to the heart again — before the rest of the blood that started with it has had time to go through the longer arteries. These differences in route and speed need not confuse us at all; they will only add to the interest of the picture if the following outline of what happens is kept clearly in mind. Whatever route be taken, whether to the extremities of the body, or to some

muscle very near the heart, the course of the blood is always:

1. heart to arteries
2. arteries to capillaries
3. capillaries to veins
4. veins to heart
5. heart to lungs
6. lungs to heart

QUESTIONS

1. What gives the blood its red color?
2. What do the red corpuscles do for us? The white corpuscles?
3. What part of the blood carries the digested food over the body?
4. Why does a cut always bleed?
5. What provision is made by our bodies for stopping bleeding?
6. Will a pin prick (provided it is deep enough) draw blood wherever it pierces the skin? If so, what does this show about the blood vessels?
7. To what two men do we owe much of our knowledge of the way in which the blood flows through our bodies?
8. What three sets of tubes are used to carry the blood? What are the capillaries?
9. Describe the journey that the blood takes on its circuit from the heart and back again.
10. Does all the blood that the heart pumps out at one time travel the same distance?
11. What would be the longest distance that a drop of blood could travel in the body?

To the Teacher. If possible, have pupils examine a drop of blood under the microscope.

CHAPTER II

THE HEART AND THE CIRCULATION

The Heart as a Pump. — It is easy to find the spot at which the heart beats; that spot is where the apex or lower point of it comes. If you put the little finger of your right hand over that spot and your thumb in the hollow in front of your neck, the heart will lie under your

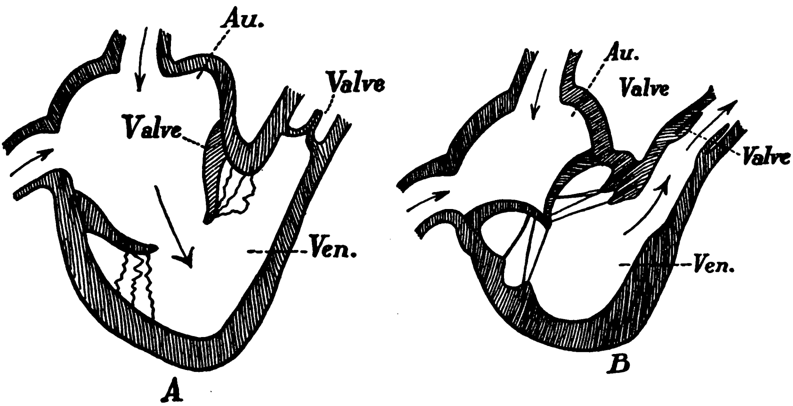


FIG. 28. — THE VALVES OF THE HEART.

The right side of the heart shown diagrammatically. *A* represents the time when the blood is flowing into the auricle and the ventricle from the veins, and *B* the stage when the ventricle is contracting to force the blood into the pulmonary arteries. *Au.*, auricle; *Ven.*, ventricle.

hand. It is about the size of your fist, but pear-shaped, with the upper and larger end lying in the middle of the

chest and the lower end turned to the left, where you feel it thump.

The heart is a muscle, or rather a group of muscles so arranged that they work like a pump. In fact, the heart is a double pump, for there is a partition running up and down, which really divides the heart into two hearts; they are attached to each other, but so separated that no drop of blood can flow from one side to the other. On one side is the pure blood which is to go out into the body; on the other side is the impure blood which is to go to the lungs. Each side of the heart has two cavities, as shown in Figure 28. Those on the right side are called the **right auricle** and the **right ventricle**, those on the left, the **left auricle** and the **left ventricle**. The muscles of the left ventricle are much stronger than those of the right because it has to pump harder.

The Heart Beat. — As long as a person lives, whether he is awake or asleep, his heart continues to pump blood through the blood vessels; the motion of the blood and the work of the heart never cease. In order to pump continuously, the heart evidently must be adjusted so that it can work with the least possible amount of effort. It is not surprising, therefore, to find that the heart takes a little rest after every beat, really resting longer than it works.

What we call the " heart beat " means simply the contraction of the muscles; this contraction squeezes the blood out into the blood vessels. Little gates, or **valves,** opening only one way, determine the direction of the blood flow. A study of Figure 28 will easily show why, when the heart beats, the blood is forced in the direction

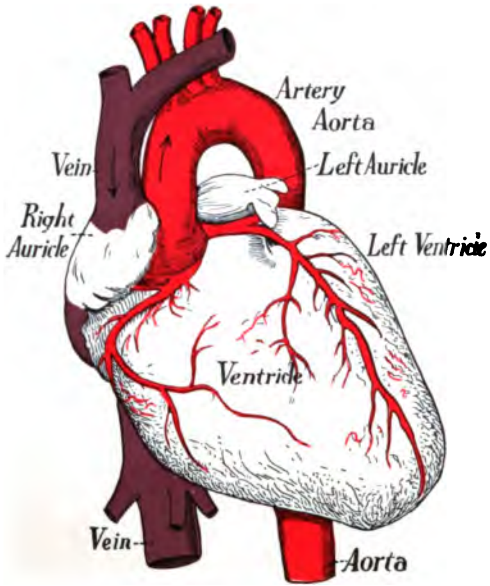
of the arrows and how it is prevented from flowing backward. As soon as the heart relaxes from its contraction, blood flows into it again from the veins. A grown person's heart beats from 70 to 80 times a minute, a child's heart beats faster, and a baby's as fast as 120 times a minute. The heart beat is firm and strong when one is in good health; when one is ill it becomes weak.

The Pulse Beat. — Each time the heart beats, and so forces the blood into the arteries, the pressure produced is felt through the arteries and causes them to swell slightly as the blood passes. The artery at the wrist is so near the surface that we can feel the swelling there. This we call the **pulse**. There is a pulse in all the arteries, but the throbbing cannot readily be felt in most of them as they are deep in the muscle. The wrist is the best place for testing the pulse beat, but it can be felt at the neck, just under the lower jaw, and also at the temples. Physicians feel the pulse of a sick person, for this tells them a great deal about the general condition of the patient.

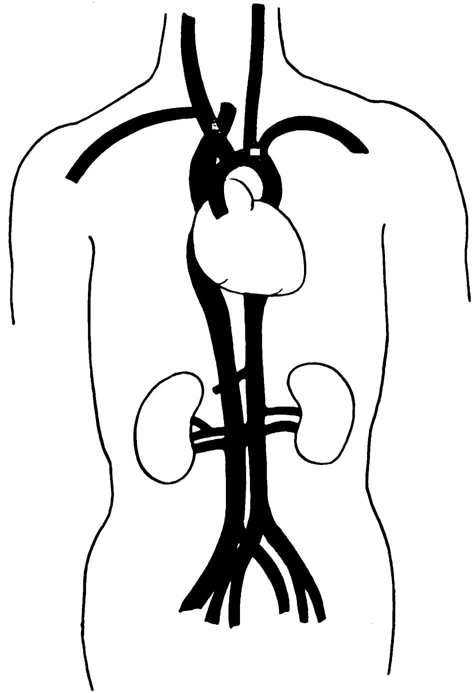
When the heart beats, both sides act at the same time, each doing its separate work. Let us trace what happens, from the time of one heart beat up to the time when the heart is ready to beat again.

Work of the Left Side of the Heart. — Before the beat comes, the left auricle, which is really a reservoir, contains bright red blood; it contracts and sends this blood into the left ventricle; then the ventricle contracts and forces out all the blood that is in it.

Blood in the Arteries. — The blood passes into a large **artery** which is shown in red in the colored illustration opposite. This artery gives off some large branches (to



THE HEART AND LARGE VESSELS CONNECTED WITH IT



THE HEART AND CHIEF BLOOD VESSELS OF THE BODY
The figure also shows the kidneys.

the head and arms) and then runs down the body, giving off branches all the way. The branching arteries also give off smaller branches until finally they become thousands of minute tubes which enter every organ of the body. This does not mean that all the large arteries are in the upper part of the body, and all the small ones in the legs; there are tiny artery branches in the chest, near the heart, as well as in the extremities.

Blood in the Capillaries. — The blood goes through these artery branches until finally they end in even smaller tubes, the capillaries, like those shown in Figure 29. These are too small to be seen except with the aid of a microscope; some of them are so small that the corpuscles, tiny as they are, have to go through in single file. It is while the blood is in these capillaries that it gives up to the living parts of the body the food materials which it holds. Every part of the body is filled with capillaries, and every part gets its share of the food which passes out through their delicate walls. Here again, we see the smallest parts doing the most important work; the heart is a giant compared with the capillaries, but its work is performed chiefly to supply them with food.

FIG. 29. — CAPILLARIES.
Showing the end of an artery, capillaries, and a vein arising from the capillaries.

Blood in the Veins. — After its journey through the capillaries, where it not only leaves the food but also takes up waste matter, the blood is ready to go back to the heart. It needs to be purified before it can be of further use to the body. So the little capillary branches combine to form the larger blood vessels called **veins**; and the veins keep combining (just the opposite of the arteries, which kept branching), until finally they unite in two large veins, which pour the blood into the right auricle of the heart.

Work of the Right Side of the Heart. — At the same time that the left ventricle contracted, the other ventricle, the right one, was also making its contraction. The right ventricle sends the blood to the lungs to be purified; this is a much shorter trip than the journey around the body. At every heart beat both ventricles contract; the left one sending pure blood out to the body, and the right sending impure blood to the lungs to be purified. From the lungs the purified blood goes to the left side of the heart, ready to be sent out again to the body.

The path of the blood is always this: out from the left side of the heart to feed the body and gather up wastes; then to the right side of the heart, to be sent to the lungs for purifying; then back again to the left side to go out again to the body. A grown man has about six quarts of blood; at each beat of the heart about half a cup full of blood is sent out to the body from the left side of the heart and half a cup full is sent to the lungs from the right side.

Relation of Arteries and Veins. — The arteries lead away from the heart, and all of them, except those that

go from the heart to the lungs, *carry pure blood.* The veins lead to and enter the heart; all of them *carry impure blood,* except those that go from the lungs to the heart. The arteries are embedded deep in the muscles; the veins are nearer the surface. A cut in the flesh is almost sure to cause bleeding from the veins, but it takes a very deep cut to injure the arteries. If you will let your hand hang down for a minute, you can see the position of the veins by the blue lines that will appear on the back of the hand. If you wind a rubber band tightly around one of your fingers, the finger will soon become dark colored, being gorged with blood. From the facts given above can you explain why the finger becomes a dark red instead of a bright red?

The Feeders of the Body. — The **capillaries** are the smallest and the most important of the blood vessels. The chief purpose of the heart, the arteries, and the veins is to keep a supply of good pure food and oxygen going to the capillaries, so that they may feed the body. Remember that they are not away off at the end of some long line of arteries, but that they are everywhere, in all parts of the body; if there were any part that had no capillaries, it would starve and die.

Lymph, in and around the Capillaries. — As the blood goes through the capillaries, the red corpuscles give up their oxygen. The oxygen passes out through the thin walls of the capillaries; but the red corpuscles themselves never leave the blood vessels, except in case of accident. Some of the liquid part of the blood, however, does ooze through the capillary walls into the spaces around them. This clear and watery liquid is really the blood plasma,

which is then called **lymph**. The lymph actually bathes the living parts of the body; and as it contains the dissolved food that was in the blood, it can give this food directly to the parts of the body that need it.

FIG. 30. — LYMPH VESSELS IN THE ARM.

At the same time, the lymph receives from the living tissues the waste materials they have produced as they worked. These must be carried away or the tissues cannot go on working. The flow of the lymph is not nearly so rapid as that of the blood, but slowly it moves away from the living tissues carrying the wastes it has taken up, its place being taken by fresh lymph from the capillaries. Gradually the lymph collects in tiny tubes, called **lymph vessels**, and these unite finally in two large vessels that empty into the veins in the neck. Thus in the end, the lymph again becomes a part of the blood plasma in the blood vessels. Little organs called **lymph glands** are found along some of the lymph vessels; they may perhaps help to filter out some of the wastes. Because it carries away the wastes, the lymph system has sometimes been called the drainage system. This name, however, describes only half its work, for it is as much the mission of the lymph to carry food to the living parts of the body as to carry off the wastes.

QUESTIONS

1. Describe what you would see if you could cut the heart in two lengthwise and look into it.

2. Suppose a drop of blood is entering the left auricle. Describe the journey that it takes before it reaches the left auricle again.

3. What do you think would happen if the heart valves did not work?

4. With your left hand grasp your right wrist, pressing the thumb firmly against the lower end of the radius or bone on the thumb side of the arm. Count the number of beats that you feel in a minute.

5. What is this throbbing movement called, and why can it be felt so plainly at the wrist? Where else can it be felt?

6. What can you tell about the heart from feeling the pulse?

7. What is the work of the capillaries? Why are these tiny vessels so important?

8. In what respects is the blood in the veins different from the blood carried by the arteries?

9. Why is it that when you cut your finger the blood that flows from it is likely to be a very dark red?

10. What is lymph? Where does it come from and where does it go? What two duties does it perform?

To THE TEACHER. Borrow a stethoscope from some physician if you can and have pupils determine with it the location of the heart and the strength of its beat.

CHAPTER III

THE CONTROL OF THE BLOOD FLOW

Differences in the Heart Beat. — The body is able to regulate, not only the *rate* at which the heart shall pump the blood, but also the *size* of the blood vessels and so the amount of blood carried in them. Usually all this occurs without our being in the least aware of what is happening, nor could we, however hard we tried, make the heart beat slower or faster. A simple test will show decided differences in the heart beat. (1) Count your pulse after you have been sitting still studying for half an hour; write down the rate. (2) Go out and run around briskly for five minutes; then count the pulse and record the rate. (3) Go in and sit still for twenty minutes; again record the rate. (4) Stand still, and see whether you can make your pulse go ten beats faster by thinking about increasing it. Three of your records will doubtless be somewhat like these:

When sitting, about 85 beats per minute.

After running, about 115 beats per minute.

After sitting still twenty minutes, about 90 beats per minute.

Did you find that you could increase the rate of your heart beat by thinking about it? No, and yet it was increased when you were running; how this is done can be more satisfactorily explained later.

How Each Organ Gets Its Blood Supply. — Not only will the heart beat faster if the whole body needs more blood to use, but each separate part of the body is furnished with a larger or smaller supply as needed. This may be seen from a few simple tests. (1) Bare the arm, rub it briskly, and notice how red it turns. That is because more blood is flowing through it than usual. (2) Place the arm in hot water and it will become red in the same way for the same reason. (3) Put the arm in cold water and it will turn white, since less blood flows through it than usual. (4) When a person blushes, it is because more blood than usual is allowed to go through the skin of the cheeks; when one turns pale, less blood than usual is sent through.

The fact is that the brain, which is a wonderful organ, has the power to send the blood to any part that needs it. When an organ begins to work vigorously, it gets an extra blood supply; and, in consequence, the other organs cannot get quite as much as usual. If the brain begins to work hard, it receives more blood, and the arm, which then receives less, actually shrinks a little in size, as can be proved by delicate tests. When the brain goes to sleep it shrinks a bit, as it needs and receives less blood.

Changes in Blood Supply. — One very interesting case is that of a man who, by an accident, had a bit of the skull removed in such a manner that his brain could be seen and watched. It was found by testing him that the amount of blood going to his brain increased and decreased regularly according to the work his brain was doing. When he was asleep it received very little, but the moment he waked a greater supply was turned into the brain.

In the same way, every organ gets an extra supply of blood when it begins to work, and it cannot do its best till it gets its full supply. If the foot, the arm, the legs, or the stomach are to do hard work, the first thing that must happen is for the brain to send them an extra blood supply. It is evident, therefore, why an athlete finds it helpful to run about, to "warm up" as he calls it, before the race begins; this "warming up" starts the blood flowing through the muscles he is going to use, so that when the race is called his muscles are ready to work hard. Every change in occupation changes the distribution of the blood in the body, so that the parts to be used get more blood and the other parts less. This change is made by means of the tiny muscles in the blood vessels, which cause them to become larger or smaller. Of course this is done without our attention or knowledge, even though it is controlled by the brain.

Through its ability to regulate, quickly and accurately, the amount of blood sent to different parts of the body, the brain also regulates the temperature of the body.

A Good Circulation. — It will not do much good to have pure blood unless it is kept circulating rapidly, and so the heart must be kept strong. Like any other muscle the heart grows stronger by use. Of course it is really beating all the time, and so is always being used to some extent. But vigorous exercise, like running, makes it beat faster and stronger, and it is strengthened by the extra work. On the other hand, a quiet life, a "sedentary life" as it is called, weakens the heart because it does not have enough to do. Exercise is the best "stimulant" for a healthy heart; drugs that act on the heart really

weaken it, though some of them may make it beat a little faster for a short time.

The Need for a Good Heart. — If a boy wants to stop a runaway horse, he may think that what he needs most is good leg muscles with which to run and a clear head to decide what to do. But his ability to run depends more upon his heart than upon his legs. An athlete knows that his winning depends more upon his heart than upon his arms or legs. When any special need comes, the muscles will work sufficiently well if the heart is strong enough to send the blood through the body rapidly enough to carry away all the poisons that accumulate as the muscles work. There are many emergencies in life which require some sudden exertion; the heart that has been exercised every day by doing extra work is ready for these emergencies.

Sensible Training of the Heart. — Work is good for the heart, but it is not wise to work it until it is overtired. Long-continued and severe exercise is apt to strain and weaken it. Very long runs or long-continued use of a jumping rope will weaken the heart instead of strengthening it. Sometimes the heart is so overworked as to weaken it for life. One athlete tried to strengthen his heart by running up-stairs repeatedly; instead, he so overstrained it that it failed him when the contest for which he was preparing came, and he found himself permanently weakened by the injudicious exercise he had taken. Growing boys and girls need to be particularly careful in this respect, for their hearts are not ready for long-continued exercise. A six-mile walk is better than a twenty-five-mile walk. Plenty of light, active exercise,

not taken for too long a time, is the best means of building a strong heart.

Drugs to Be Avoided. — Tobacco and alcohol are two drugs that act directly upon the heart in such a way as to weaken it. That explains why the boy who smokes cigarettes, and thus acquires a "cigarette heart," can never in all his life be as strong and as vigorous as he would otherwise be; his heart is permanently weakened. Every one knows that the boys who are training for athletic contests are forbidden to smoke; and even on university teams, made up of grown men, no trainer would allow the use of tobacco or alcohol; he wants to have his men "fit to win." Many occupations that require active muscular work and real endurance are closed to a man with a weak heart; he is restricted to "light work." What boy wants to be in that condition? Life insurance companies will not issue a policy to one whose chances of a long life are so poor.

Fainting. — The ease with which the blood distribution is changed has some unpleasant results and one of them is **fainting**. When a person faints it usually means that the brain is not getting blood enough, thus causing unconsciousness. The remedy is to get the needed blood into the brain again. Placing the head a little lower than the body helps to bring this about, for then the blood tends to run into the brain from its own weight. Usually lowering the head is all that is needed, and as soon as the necessary amount of blood has reached the head the person recovers consciousness; sometimes it is best to stimulate the action of the heart, which can usually be done by dashing a little cold water upon the face.

When anybody faints, one natural impulse is to lift the person's head, which as a rule hinders recovery. Another impulse is to crowd around the fainting person, thus shutting off the fresh air that such a person particularly needs. The blood will not fail to go to the brain in sufficient quantity unless seriously impeded; the trouble may be due to improper eating, lack of exercise, or wearing around the waist a corset or a belt that is too tight.

Some people faint more easily than others, but the habit may usually be overcome if proper attention is given to the ordinary rules of health. Some become frightened when they feel faint. The sensible thing is to regard faintness as a signal from the brain that it needs more blood, and to proceed at once to help it get more. To fall over in a dead faint is frequently sheer heedlessness and quite unnecessary. One who begins to feel very faint should either lie down for five minutes, if that is possible, or else sit down and rest the head on the knees — both positions help the blood to flow into the brain. A resolute determination not to faint is also a decided help in all simple fainting attacks; occasionally, fainting is the first symptom of a serious illness, and then it cannot be so readily controlled.

Bleeding. — The heart sends the blood into the main artery in spurts, pumping it with force. The arteries, being elastic like rubber, stretch a little as the blood flows into them, and the result is that a short distance away from the heart the blood begins to flow more smoothly; and, by the time it has passed through the capillaries and is on its way through the veins, the spurting has ceased entirely.

If an artery is cut, the blood flows out very rapidly in strong jets; the bleeding must be stopped quickly, or the person will bleed to death. If a vein is cut, the bleeding is not so rapid and consequently is not so dangerous. But in any case it must be stopped, for even through a wound in a vein enough blood to cause death might be lost if the flow were not checked. To lose a few teaspoonfuls of blood is not serious; it may make one faint for a few moments, but that feeling will quickly pass. Every one ought to know how to tell whether the bleeding is slight and will take care of itself, or whether it is serious and needs instant attention if the life of the bleeding person is to be saved.

How Bleeding Is Stopped. — In most accidents that cause bleeding only small veins or capillaries are cut, and the result is not serious. Nature has made provision for taking care of such cases, for as soon as a blood vessel is broken or injured the blood starts to work to close the wound. If it is a small one, it will soon be more or less completely stopped with a plug of blood called a **clot.** It is believed that the **blood plates** are concerned in causing the blood to clot. This process can be helped by bringing the edges of the wound together and binding them tightly with a strip of clean cloth, or a piece of surgeons' plaster, until the bleeding stops. If there is much bleeding, the plaster will not stay on, and in that case the cloth is better. For a time the blood may ooze through the cloth, but even deep wounds in the veins will usually stop bleeding if the wounded part is kept quiet and the cloth (called a ligature when so used) is drawn as tightly as possible. The tight ligature will close the

broken blood vessel and help keep the blood still until it can clot.

We can see what the clot is like by observing some blood drawn into a small dish. If it is allowed to stand for a few minutes, it stiffens, and finally the blood is changed into a firm jelly that will turn out of the dish as one mass; in other words, the blood has clotted. The blood will not remain liquid after it has been drawn from the blood vessels. Keeping it warm will not prevent its clotting; nor will warming it make it liquid again after it has clotted.

FIG. 31. — ARTERIES IN THE ARM.

Bleeding from Arteries. — The arteries lie so deep that they are not often injured, but when they are cut the case is serious; a person's life may depend upon the promptness and efficiency of some chance bystander. If the blood comes in spurts from a cut or wound of any sort, an artery has been injured. There is no hope that the clot can be formed quickly enough to stop the flow from an artery.

FIG. 32. — ARTERIES IN THE LEG.

This artery is in the front of the leg above the knee, but behind it below the knee.

The only way to stop the bleeding is to check the flow of the blood into the broken part of the artery; this is done by compressing the artery above the cut, that is, between the heart which is pumping the blood into the artery, and the cut where it

FIG. 33. — SHOWING THE METHOD OF GRASPING THE ARM TO STOP BLEEDING FROM AN ARTERY.

is running out. The arteries in the arms and the legs are more liable to injury than others, and the treatment in such cases is simple. Figures 31 and 32 show the course of the chief arteries in the arm and the leg. Figure 33 shows a simple method of grasping the arm so as to compress the artery; this will temporarily stop arterial bleeding in the arm anywhere below the elbow.

While one person is compressing the artery, another should make a ligature and put it around the arm above the cut, placing a stick inside it, as indicated in Figure 34. The stick should then be turned, twisting the ligature more and more tightly, until the bleeding stops. Less pressure will be required if a stone or a tightly rolled handkerchief is placed under the ligature and over the artery. A physician must also be summoned as soon as possible, to tie the artery. With a wound in the leg, the method of stopping the flow is similar. Do not wait for help, or to send for anything; use whatever is at hand and work quickly.

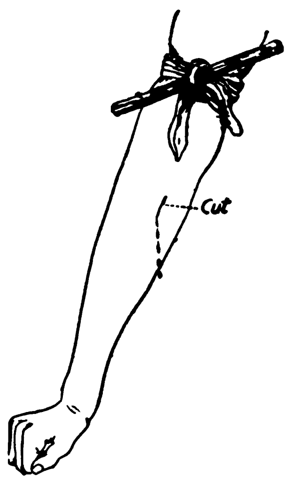


FIG. 34. — SHOWING THE METHOD OF APPLYING A LIGATURE TO THE ARM.

Bleeding from Veins. — Sometimes when a large vein is cut,

the blood flows so rapidly that it must be speedily stopped to save life. The blood from a vein is dark colored and does not flow out in forcible jets. To stop the bleeding a ligature should be applied, but it should be placed *beyond the cut*, leaving the cut between the bandage and the heart. Can you see why?

Diseases of the Blood

Pure Blood. — It must now be clear that it is important to keep the heart strong and to have good, pure blood circulating through the body. We sometimes speak of "life blood," and this term is a good one, for every action of the body depends on the blood. It is frequently said that a person's blood is in bad condition, and we hear of medicines to "tone up the blood." Usually the trouble in these cases is not with the blood at all, and the medicines, if they have any value, are useful to "tone up" the vitality of the whole system and incidentally that of the blood. Most "blood purifiers" are simply patent medicines given this name to catch attention and to get money from the unwary. Food, air, sleep, and exercise are the real "blood purifiers." A class of troubles called "blood poisoning" can be better considered later. There are two diseases associated with the blood that should be mentioned here.

Anæmia. — Sometimes people, especially young people, become very pale and the skin may even look waxy; they lose their vigor, grow weak, and are unable to do their ordinary work. The doctor says they are **anæmic.** The trouble is usually either that their blood contains too few red corpuscles, or that the corpuscles contain too little

hemoglobin. The remedy is a general building up of the body, and such cases require the care of a physician.

Malaria. — *Malaria, chills and fever, fever and ague,* are different names for the same disease; it is caused by tiny parasites in the red corpuscles of the blood. The disease is found all over the country and, in fact, in most parts of the world; it is, however, most prevalent in hot climates. Its most common symptom is the appearance of a chill followed by a fever. These periods come with regularity. Usually there is one "chills and fever day," followed by a day in which the person feels better; then the next day he has another chill with its fever. There are cases in which these attacks come every day or every three days.

The disease is common around swamps, and it was for a long time supposed to be caused by breathing damp air, particularly the night air of certain infested localities. Then physicians studied the cases, especially in places where numbers of people had the disease; after many experiments, the germ of malaria was discovered. The tiny parasite lives part of its life in the mosquito and part of it in the human blood. When a mosquito having some of these germs in its body bites a person, the germs are carried into the blood, and unless they can be destroyed there, he will soon become ill with malaria. These germs are carried by only one kind of mosquito, called *Anopheles* (see Fig-

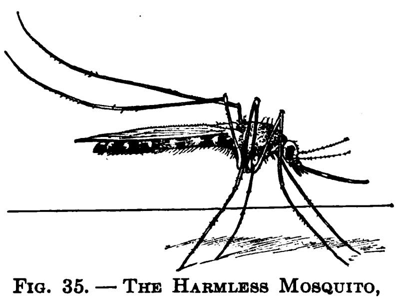


Fig. 35. — The Harmless Mosquito, Called *Culex*.

ure 36); fortunately this kind is less common than the more harmless one, named *Culex* (see Figure 35). Moreover, even the Anopheles is not dangerous unless it has previously bitten some one who has malaria, and so has sucked into its body blood containing the germs, for the mosquito must be infected from the human being.

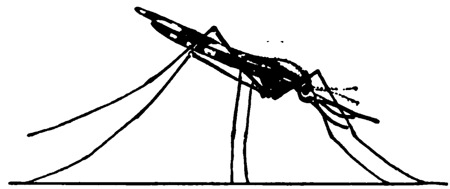


FIG. 36.—THE MALARIAL MOSQUITO. Notice that the body and head lie in a straight line. This is not true of the *Culex* shown in Fig. 35.

Malaria can therefore be prevented by protecting ourselves against mosquito bites. Mosquito nettings at windows and doors are a good precaution. The destruction of the breeding places of the mosquitoes is more effective, however. For the protection of a family it is better and cheaper to dig a ditch that will drain a stagnant pool than to buy pounds of quinine, as a medicine. Stagnant water is the incubator of the mosquito and the rain barrel his cradle; even a tin can may harbor a host of these pests. Pools may be made temporarily harmless by putting kerosene on the surface; it will spread rapidly and smother the mosquito young or wigglers, as they are called. Rain barrels should be covered with mosquito netting, or turned over when not in use so as to give no opportunity for the mosquitoes to breed in the water; tin cans should be emptied and thrown away where they can do no harm. As fast as mosquitoes disappear malaria disappears also. *No mosquitoes — no malaria.* It is important to remember that the malaria mosquito flies only

at night. So there was some basis for people's fear of night air, only they were fearing the wrong thing. Night *air* is not injurious, though night *mosquitoes* are; and if we use mosquito nettings we may keep the windows open all night without fear.

Other Diseases Distributed by Insects

Yellow Fever. — *Yellow fever* is not regarded as a disease of the blood; it is mentioned here because, like malaria, it is distributed by mosquitoes. It is a very serious disease, is often fatal, and is found chiefly in tropical climates. Occasionally it has been brought to our southern states, producing frightful epidemics and killing thousands of people.

A few years ago three scientists went to Cuba to study the disease. They concluded that it was carried by mosquitoes and to test the truth of their theory they allowed themselves to be bitten by the kind of mosquitoes that they suspected; two of them took the disease in that way, and one died of it. Later several others submitted to a similar experiment, and some of these also died of the frightful disease. The death of these heroes, as brave as that of soldiers in battle, has been of great benefit to mankind; it has shown that to fight the mosquito is to fight yellow fever. The mosquito that distributes this disease is not

Fig. 37. — The Yellow Fever Mosquito.
Note the striped legs. It is really a much smaller mosquito than *Anopheles*.

the common mosquito, nor is it the one that carries malaria. From Figure 37 you can see that the yellow fever mosquito has striped legs.

To stop yellow fever, the breeding places of mosquitoes are either destroyed, or so covered that mosquitoes cannot get into them to lay their eggs. The patients, too, are guarded from mosquitoes, since it is only by biting a patient that the insect obtains the germs and can thus carry the disease. Since yellow fever has been fought in this way, the disease has lost most of its terror. In Havana and in Panama, yellow fever was always present before this discovery, but now it has practically disappeared. One epidemic which started in New Orleans was quickly stopped after the people began to fight mosquitoes. Since mosquitoes are the means of distributing two most serious diseases, they ought to be recognized as our deadly enemies. Money spent in their extermination is well invested, and every one should be glad to aid in the work of destroying them.

Bubonic Plague. — There is another very fatal disease that is distributed by an insect bite, though it is not specifically a disease of the blood. It is called the **bubonic plague**. This is common in some of the eastern countries, but as yet the United States has fortunately had very little of it. This disease is usually distributed by two animals, the rat and the flea. Rats acquire the disease from human beings, since they eat all manner of foul material containing human excretions. Then fleas, which are common in the rats' fur, become contaminated with the germs by sucking the blood of an infected rat. If those fleas later jump from the rat to a human being

and bite him, the germs are carried to him and so the disease is spread. The successful way to fight this disease is to exterminate rats. Ships coming to this country from ports where the disease is prevalent are frequently required to stay at some distance from our docks, and to land their cargoes in small boats, so that the rats in the ship may not get ashore and perhaps be the means of starting an epidemic of the disease.

QUESTIONS

1. Why does a quiet life lead to a weak heart?

2. When do you think there would be a large supply of blood in your brain? When a very small supply?

3. Do you see why it is difficult to study after eating a hearty meal?

4. Will the temperature of a person's body rise when he runs? Can you explain why he feels so much warmer?

5. If a person gets out of breath very easily when walking rapidly, is the trouble in the heart, lungs, or in his muscles?

6. Why is rubbing the feet a better remedy for cold feet than warming them at a stove?

7. Colds are accompanied by too much blood in the lungs or the air passages. Can you tell why soaking the feet in hot water may relieve a cold?

8. Why is an athlete forbidden to smoke tobacco or use alcohol when he is training for an athletic contest?

9. What would you do to revive a person who has fainted? Explain why raising the head is the worst thing to do.

10. Why is bleeding from an artery more dangerous than bleeding from a vein? What would you do if you had a cut in the arm and found that the blood came out in forcible jets? Why would you need to hurry?

11. Can you give any reason why people living near swamps are especially liable to malaria?

12. If there were yellow fever in your neighborhood, how would you go about fighting it?

CHAPTER IV

WHAT BREATHING DOES

EVERY minute, all day and all night, a person breathes from twelve to eighteen times. He can hold his breath at will for about a minute, but not longer, or he can breathe faster for a while; but the time will come when the body will rebel and will work the breathing mechanism properly, even against his will. This shows that breathing is absolutely necessary to the body.

It is difficult to learn much from watching our own breathing, because as soon as we think about it we stop doing it naturally. Observing somebody else, one finds that the breath is drawn in, **inhaled**, and held for about a second, then it is **exhaled** (breathed out); then there is a pause of a second or two for rest, before the process is repeated. Two exceedingly important things happen during the very brief time that the air is in the body; oxygen is taken out of the inhaled air, and another gas, named **carbon dioxid** (a waste product), passes into it. The body *must get rid of carbon dioxid,* and it *must have oxygen* for the millions of living cells that are carrying on the work of life. So the process of breathing, called **respiration**, is an exchange of gases between the body and the outer air.

What We Breathe With. — Under ordinary circumstances breathing goes on regularly without any effort

on our part, and yet nearly all the organs of the body are directly or indirectly involved in it. Breathing might be said to be the main business of the nose, the throat, the windpipe, the lungs, the diaphragm, and the ribs.

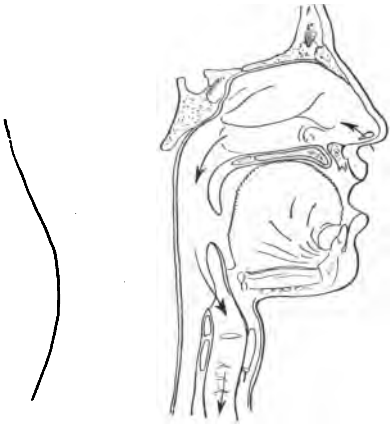


FIG. 38. — A SECTION OF THE HEAD. The figure shows the air passages from the nostrils to the windpipe; the arrows show the direction of the air.

The Air Passages. — Air should be taken in at the nostrils, not at the mouth. From the nostrils it passes through the nasal cavities, the surfaces of which are always moist. In passing through them, the air is warmed, and much of the dust in it, which often holds bacteria, is caught on the moist surfaces. Any one can prove this by vigorously blowing his nose into a handkerchief after he has been breathing air that is full of dust; it will be seen that much dust is thus blown on to the handkerchief.

Mouth Breathing. — When one breathes through the mouth, the air, entering more easily, passes in so rapidly that the mouth and throat can catch only a little of the dust and it is carried on into the lungs, where it is likely to do injury. One should avoid getting into the habit of mouth breathing; even when walking fast or running, one should always breathe through the nose. It may seem as though one could run better if one took in breath

by the easiest way, but mouth breathing is easiest only for a short time; then the mouth and throat become parched; the runner gets "distressed" and perhaps has to stop running. No trainer of an athletic team will allow one of his runners to breathe through the mouth. Frequently trainers find that a man has some little growth in the throat that is partly closing the nasal passages and so making natural breathing difficult. These growths are called **adenoids**; they are common and are readily removed. Any one who cannot breathe easily when the mouth is closed should have a physician examine his nose and throat, for mouth breathing is a serious menace to health.

FIG. 39. — THE EFFECT OF MOUTH BREATHING. Two pictures of the same person, showing the effect of mouth breathing; the figure on the right being taken after the removal of the adenoids, and the correction of the misshapen jaw which resulted from the improper method of breathing.

The Windpipe. — From the nasal passages the air goes into the throat, passing down behind the soft palate, and past two curious little sponges, at the back of the mouth, called **tonsils**. Then it goes through the **glottis**, which is the opening into the **windpipe** (trachea), a large

air tube at the front of the neck that connects with the lungs. Just back of that air tube is another tube, the gullet or esophagus, down which the food passes to

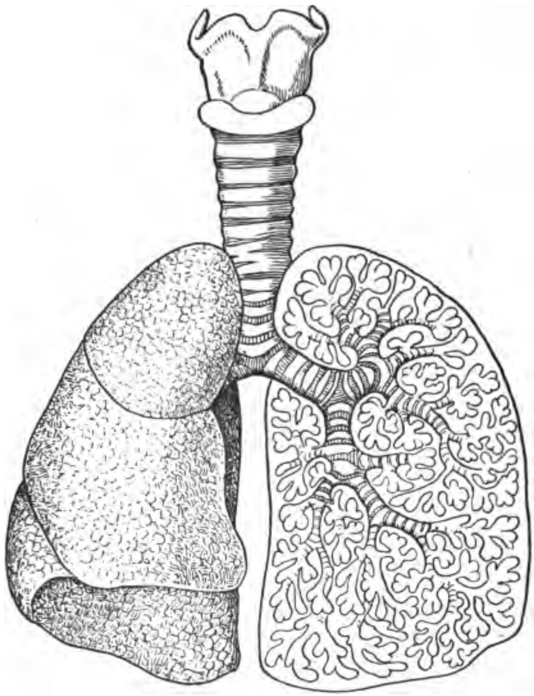


FIG. 40. — THE WINDPIPE AND LUNGS.
One lung is cut open to show the air passages and air sacs. At the top of the windpipe is the larynx.

the stomach. On its way to the stomach the food has to go by the glottis, which is fitted with a lid, called the **epiglottis**, that shuts down as the food passes, and stays lifted the rest of the time, for breathing. One of the

things that every child has to learn is that if he tries to laugh and swallow at the same time there is trouble; for at any one instant the little epiglottis cannot be both up and down, and if, when it is up to get breath for laughing, a bit of food goes past, the food may drop into the windpipe, causing one to choke until it is expelled.

The Larynx and the Voice. — At the upper end of the windpipe there is an organ called the **larynx** (see Figure 40) within which the voice is produced. The larynx is placed there not because it helps in respiration but because the same air that is used in respiration produces the voice. It is a rather complicated structure and is very difficult to understand. The chief features of it are some soft folds of the walls of the windpipe which are called **vocal cords.** If you pick up between your fingers the skin on the back of the hand, you will get a good idea of these folds. When we are simply breathing they lie flat against the sides of the windpipe. But they do not always lie flat; they are attached at their ends to some tiny hard parts, called cartilages, and to these tiny muscles are connected.

When the muscles contract in the right way the folds are lifted away from the walls and pulled out toward the center of the air passage, so as partly to close it. Then when we force the air out of the windpipe it has to pass through the rather narrow slit that is left between the cords, and this blast of air sets the cords shaking rapidly, or as we say, sets them *vibrating*. The vibration of the cords produces the tones of the voice when we speak or sing, somewhat as blowing upon a blade of grass held between the thumbs produces a sound.

If we want to sing on a higher note, we give a little pull to some of these delicate muscles, and that stretches the cords a bit tighter so that they vibrate faster. If we wish a lower tone, we relax the muscles so that the cords slacken and vibrate more slowly. When you first tried to sing you could not control these muscles well enough to make the right tone. But practice has made it easier. A good singer has acquired a most wonderful control over these tiny muscles and is able to produce a great variety of tones very accurately. If we wish to speak loudly we blow a strong blast of air over the cords; we speak gently when we blow only a feeble blast of air over them. If we simply wish to breathe without using the voice, we let the cords flatten back against the sides of the larynx so that they do not vibrate at all in the air.

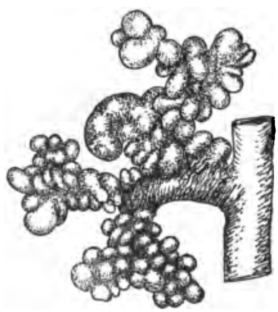
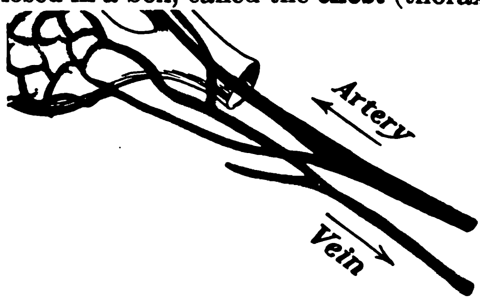


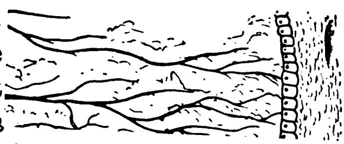
FIG. 41. — A CLUSTER OF AIR SACS.

Air Tubes in the Lungs. — When the windpipe enters the chest it divides into two forks or branches, one turning to the right and the other to the left; each branch, then called a **bronchus**, enters an irregular shaped elastic bag which is called the **lung** (right lung or left lung). Each bronchus is a hollow tube which divides again and again until it has tube branches that are much smaller than the smallest twig; each of these tiny tubes ends in a bunch of small rounded **air sacs**. Imagine a hollow tree, with no roots, standing with its trunk up and its branches hanging down, every branch and twig hollow and each twig ending

in a cluster of leaves which when blown up form hollow bladders. That is much the way the air tubes and air sacs hang in the lungs. They make the lungs light and spongy.

The Lungs. — The lungs are well protected from injury; they are inclosed in a box, called the **chest** (thorax), which has the breast bone (sternum) and the ribs on its front and sides to make it strong. Figure 42 shows the chest with the lungs; they need the bony bars around them because they cannot work when they are torn or seriously injured. Notice how the bones also protect the heart; its position is outlined in dotted lines because the lungs lie over the greater part of it.





When the air taken in through the nostrils reaches the countless thousands of air sacs in the lungs, it fills some of them more or less completely. When the air is expelled, the lungs collapse somewhat; they would collapse much more if the air were all expelled, but there is a considerable amount of air in the lungs that

we cannot expel no matter how hard we try to empty them. .

Keeping the Air Cells Active. — The lungs of a well-developed grown person hold about six quarts of air; he would take in and expel about a pint of air at each
sing you could not control these muscl ich means that a
make the right tone. But practice has r orking. It is not
good singer has acquired a most wond se air sacs should
these tiny muscl enough air sacs to
produce a great may call for very
very accurately. ting or mountain
speak loudly we idle too long they
blast of air ove ey may serve as
speak gently whe s. On the other
feeble blast of ai y would be throw-
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vibrate at all in s work every day;

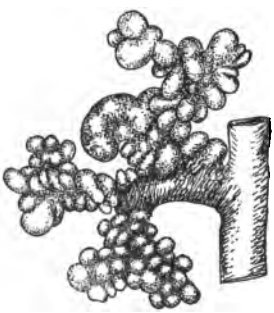
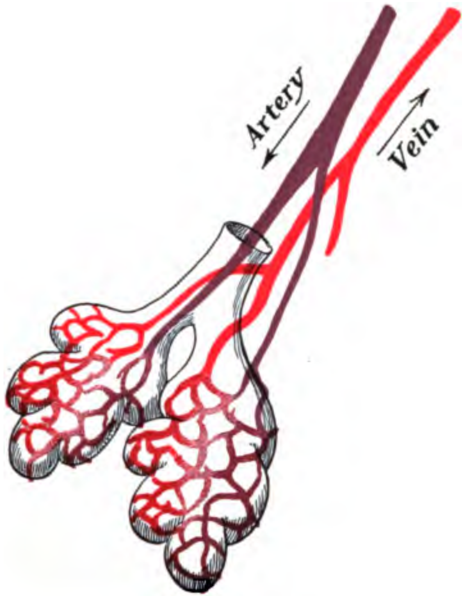


FIG. 41. — A CLUSTER OF AIR SACS.

Air Tubes in the Lungs. — When the d and coal, doing
the chest it divides into two forks or bran distending the air
to the right and the other to the left spirit. Running
and rapid walking also serve the purpose, and people who are so unfortunate as not to be able to take regular exercise out of doors may find a partial substitute by taking five minutes, three times a day, for deep breathing. They should go to an open window, unless the day is too cold, inhale as much air as possible, and then exhale it as slowly as possible, trying the next time to inhale still more air and to exhale it still more slowly and com-



Air Sacs from the Lungs.
Showing the capillaries in their walls.

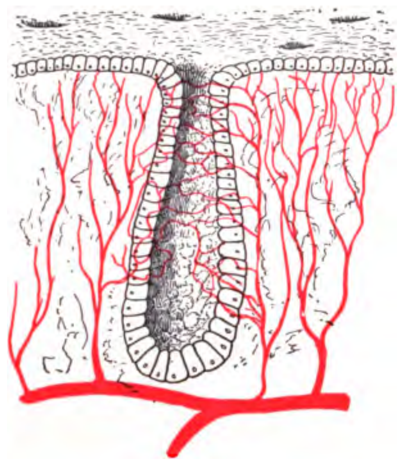


Diagram Showing a Gastric Gland with the Capillaries that Nourish It.
The opening of the gland is in the cavity of the stomach.

pletely. This should be done regularly, and with the clothing around the neck and waist so arranged that it does not limit the extent to which the chest can be expanded.

How the Blood Is Purified

Blood Vessels in the Lungs. — The large blood vessel (pulmonary artery) that carries the impure blood from the heart to the lungs, divides when it enters the lungs into small blood vessels and they into smaller capillaries, until the tiny air sacs of the lungs look as though they were covered with a fine reddish netting (see colored insert facing this page). The walls of the capillaries are very thin, and so are the walls of the air sacs; in fact, they do not prove any hindrance to the important exchanges that must take place between blood and air in order to make the blood fit for further use. Those changes may be summed up in two sentences.

What the air loses the blood gains.
What the blood gives up the air takes.

Exchanges between Blood and Air. — Both the blood and the air are very different after they have passed through the lungs. The blood has been purified, four important changes having taken place in it.

1. *The blood takes oxygen from the air.* — The hemoglobin of the red corpuscles has an affinity for oxygen, and fairly snatches it out of the air in the lungs. Then the corpuscles become a more brilliant red, and this changes the appearance of the blood from bluish red, which is the color of impure blood, to a bright scarlet.

There is 21 per cent of oxygen in the air we inhale, and the corpuscles take out nearly one-third of it, leaving 15 per cent in the air that is expelled.

Oxygen is required for all kinds of combustion. Without it the fire in the stove will not burn; nor will iron go on rusting, for even this slow, flameless combustion requires oxygen. Without oxygen the right amount of

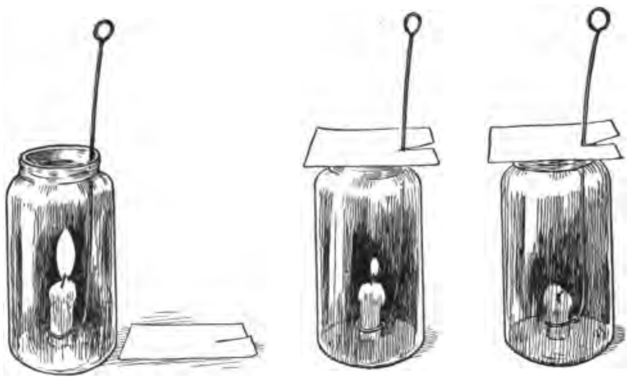


FIG. 43. — COMBUSTION REQUIRES OXYGEN.

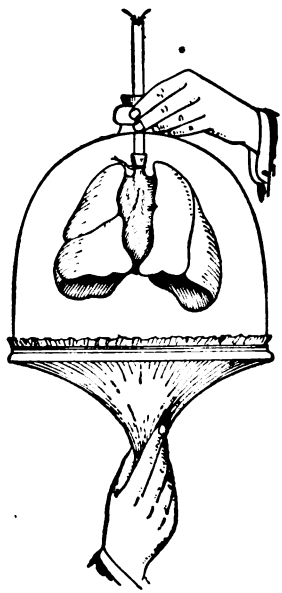
The candle burns if the top of the jar is left open, so that the air can have entrance. If the jar is covered with a paper, the candle burns lower and is finally extinguished from lack of air.

digested fuel food might be carried by the blood to every tissue of the body, and still the food would be of no use; for it is by a slow and flameless kind of combustion that the food is used in our bodies. The simple experiment illustrated in Figure 43 shows the need of oxygen for combustion. The candle in the jar goes out as soon as the oxygen is used up. The jar also becomes filled with a new gas, carbon dioxid.

2. *The blood gets rid of carbon dioxid.* — Whether

combustion takes place in the stove or in the body, it produces carbon dioxid gas, and combustion cannot continue if that gas is not removed. In the stove there is a draft that carries **shape. The front, sides,**
In the body the blood takes tm with ribs, muscles, and
tissues to the lungs; the lungs 1
send it out into the air with e
almost no carbon dioxid in th
in the air we breathe out there
of it. In case the blood did
tissues, they would be dulled a
and sickness or death would re

3. *The blood is cooled.* — D
the year, the air we breathe in
the temperature of the body.
very much cooler, and even in
indoors is (or at least ought to
cooler than the body. When
lungs it is nearly as warm a
(98.6°); it has been warmed b
and of course the blood has los
gained. This cooling of the bl
body has of regulating its tem



B

4. *The blood gives up moist*E OF THE DIAPHRAGM.
the air that is exhaled is nea to the glass tube in *A*, and when
Was it in the air that was inhas shown in *B*, air is sucked in. A
ing some air from a syringe bd for the lungs.
pane; then take a deep breath and blow it out onto another window pane. The moisture that makes the second pane cloudy comes from the blood. This does not mean that the blood gets too thin as it travels around

the body and needs to lose water as it needs to lose carbon dioxid. Giving off moisture in the lungs is another one of the provisions for regulating the body temperature.

Oxygen is required for a
out it the fire in the stov
go on rusting, for even tl
requires oxygen. Withou

FIG. 43. — COMBUS

The candle burns if the top of the entrance. If the jar is covered w finally extinguished from lack of a

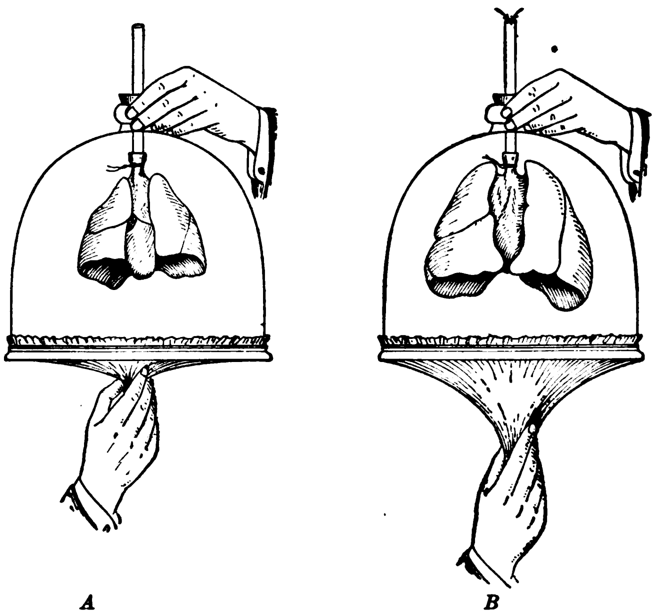
digested fuel food might b
tissue of the body, and sti
for it is by a slow and fla
the food is used in our b
illustrated in Figure 43 s

How Air Is Drawn into the Lungs. — We have been breathing ever since we can remember, so it does not seem strange to us that air can easily be taken into the lungs; yet this is done by a very ingenious mechanism. The hollow air tubes and sacs of the lungs can hold plenty of air, but they are inside the body, far away from the air; air will fill an open tube, but it will not keep on passing in and out, just so many times a minute.

A hollow rubber ball with a hole in it gives a simple illustration of the way in which air is taken into and expelled from the lungs. If the ball is squeezed, the air in it is forced out. This will show more plainly if the ball is squeezed under water. When one stops squeezing, the ball resumes its former size and shape, and as it does so, air to fill it is drawn in through the hole. In much the same way, air is forced out from and drawn into the

lungs, by making changes in the size and shape of the chest box in which the lungs are inclosed.

The Diaphragm and the Ribs. — The box that protects the lungs is irregular in shape. The front, sides, and top of it are well closed in with ribs, muscles, and



A *B*

FIG. 45. — SHOWING THE USE OF THE DIAPHRAGM.

The lungs of a small animal are attached to the glass tube in *A*, and when the rubber membrane is pulled down, as shown in *B*, air is sucked in. A collapsible rubber bag may be substituted for the lungs.

skin. At the back it is closed by the backbone and the ribs. At the bottom there is a muscular membrane, called the **diaphragm**, which extends across the chest and com-

pletely closes that end of the chest box. When the diaphragm is relaxed, it lies in an upward curve, as shown by the full line in Figure 44. When the muscles of the diaphragm are shortened, it straightens out, assuming the shape shown by the dotted line in Figure 44. This makes the space in the chest larger and fresh air rushes in to fill the enlarged space. The only opening into the chest is through the windpipe (which serves the same purpose as the hole in the rubber ball). When the chest space is increased, air is forced through the windpipe into the lungs (inhalation); the air pressure expands the lungs, and so the chest box is filled.

The mechanics of respiration can be most interestingly explained as the making and filling of a partial vacuum. With a little simple apparatus this can be made clear. Pass a glass tube through the cork in a bell glass and tie a flexible rubber bag (or the lungs of a small animal) tightly over the lower end of the tube. Close the mouth of the bell glass by tying a sheet of rubber over it very firmly. When the rubber sheet is pulled down into the position as in Figure 45 *B*, a partial vacuum is produced. Air rushes in through the tube to fill it and the bag (or lungs) attached to the tube expands.

In the enlargement of the chest box, the diaphragm is helped by the *ribs* to make the space within the chest larger. In their usual position, the ribs bend downward. When the diaphragm is lowered, the numerous muscles surrounding the ribs raise them upward and forward, thus further increasing the space within the chest. The dotted lines in Figure 46 show the position of the ribs when the lungs are full.

Little or no muscular effort is required for exhalation. After the lungs are filled with air, the muscles of the ribs relax, and the ribs fall of their own weight to the position shown by the solid lines in Figure 46. At the same time the muscles of the diaphragm relax, and it takes its former position, partly from the push given it by the liver, stomach, and other abdominal organs that were pressed out of position by the diaphragm when it was flattened down. So the motions of the diaphragm and the ribs decrease the size of the chest cavity, and this squeezes the air out of the lungs, much as we can squeeze it out of a rubber ball. The action of all these various muscles is controlled by the brain, without our being at all conscious of what is taking place.

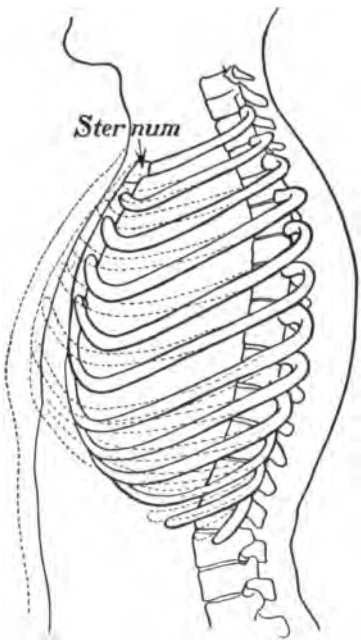


FIG. 46. — THORAX VIEWED FROM THE SIDE TO SHOW THE ACTION OF THE RIBS.

The dotted line shows the position when we inhale, and the firm line the position at the end of exhalation.

Breathing Correctly. — Most babies breathe properly, and people who work hard, whether at muscular labor or in singing and speaking, learn to use their breathing apparatus correctly. Many of the rest of us are likely to acquire lazy habits

of breathing, or to have tight bands around chest and waist that interfere with proper breathing.

There are two reasons why the diaphragm and the muscles of the lower ribs should be used: (1) Without their use certain portions of the lungs do not get any exercise. (2) The regular movements of the diaphragm are found to assist the circulation of the blood.

Singers and public speakers find that it is absolutely necessary for them to learn to use the abdominal muscles in connection with the diaphragm, in order to get tones that have both volume and carrying power.

Breathlessness and Second Wind. — Ordinarily we breathe from 12 to 18 times a minute; if we get frightened or excited, we breathe more rapidly, and any vigorous exercise, like running or hurrying up stairs, starts rapid breathing. If one goes on running, he gets breathless, begins to "pant," and breathing becomes painful. Every athlete knows that when he begins vigorous work he must go through a time, longer or shorter, in which he finds it difficult "to get breath" fast enough for the rate at which he is trying to work. He has to make a distinct effort of the will to keep up the pace that he has set for himself and it may seem as though he could not go on. Then, gradually, he feels stronger, his breath comes easier, the thumping of his heart is lessened, and he says that he has his "second wind." He can go on for some time with comparative ease. His distress in the beginning is really not due to lack of sufficient breath; it is due rather to the fact that the heart is suddenly called upon for much extra work and has not fully responded.

When the heart gets to beating rapidly enough to carry the blood around as fast as his muscles need it, his breathing is easier and he has his "second wind." If a runner cannot get his second wind, it is not usually due to weak lungs but to the action of his heart. When he is properly "trained," his heart is so strengthened that he can get the second wind quicker and can work longer than the man who is not "in training." If a person continues to be breathless when running, it means that he is working his heart too hard and may do it permanent injury. He should stop the violent exercise for a while.

Taking Exercise. — Some forms of exercise work one set of muscles and some other sets, but all of them also involve exercise for the heart and the lungs. As soon as we begin to exercise our arms, more blood runs into them. If we are using them vigorously, the heart also begins to beat faster in order to send the blood still more rapidly; then respiration becomes deeper and more rapid, for the blood is going to the lungs more rapidly and the changes that take place there must be hastened.

The lungs would have exercise enough if one did vigorous work an hour or so every day, year in and year out. But as many men and women, when they are grown, spend most of their lives indoors, it is most desirable that while young they should acquire good lung capacity; then if later their occupation gives them little opportunity for work in the open air, they will still be able, with some systematic breathing exercises, to retain the benefit of their early work. They will have strong, capable lungs.

There is also another reason why good lung expansion should be gained in youth; the heart is then most capable of doing the extra work required of it. Violent and long-continued exercise is not good for boys or girls; they need regular and moderate exercise. Lifting light dumb-bells is far better exercise than lifting heavy weights that strain and tire the muscles and may also strain and weaken the heart, perhaps causing serious trouble later on.

The Key to Health. — Exercise is really the key to health. It not only strengthens the muscles but it strengthens the heart, quickens circulation, hastens the flow of lymph, exercises the lungs, aids digestion, and makes the mind clearer for thinking. With all these advantages it should not be neglected. Between the ages of ten and twenty young people can do a tremendous amount, by regular habits of life and regular exercise, toward laying the foundation for future health and happiness.

Running has already been recommended as excellent exercise. There are many boys who would stand higher in their classes if they would run a mile every day in the open air. For city boys brisk walking sometimes has to take the place of running. Swimming is the best all-around exercise, and there are many kinds of work in doors and out that can be made the means of getting much excellent exercise. The boy or girl who lives on a farm can make a long list of healthful kinds of work. What kinds of work are there for you to do that would help in the home and also give you some of the exercise you need?

QUESTIONS

1. Can you tell why mouth breathing is injurious?

2. Name the organs upon the functioning of which breathing depends. Describe just what happens when we take in a breath of air; when we breathe it out.

3. Place your hand at your throat. Sing a few notes, pitching your voice first low and then high. Explain how the vibrations that you can feel are produced. Were they any different when you sang high from when you sang low?

4. What is the use of the air sacs in the lungs? What effect will running have upon the air in the air sacs?

5. What four changes take place in the blood after it enters the lungs? What changes take place in the air?

6. What color would you think the blood of a person would be who had died of suffocation?

7. Do you think the blood would be cooled by rapid breathing on a hot summer day when the thermometer was 105 degrees?

8. What effect would a tight belt or a tight corset have upon breathing?

9. What kind of games should be avoided by a person who has difficulty in getting his "second wind"?

10. Mention all the advantages you can think of that come from taking regular exercise.

To the Teacher. Have pupils take each other's chest measurements, noting the number of inches of expansion when a deep breath is taken in.

Have pupils perform the experiment with the candle described in this chapter.

Another interesting experiment to illustrate how the air which we breathe out has been robbed of oxygen is as follows:

Place a piece of cardboard over the mouth of a fruit jar. Through a hole in the cardboard insert a glass tube. Breathe through the tube in and out from the jar several times. Carefully invert the jar over a lighted candle allowing as little air to escape as possible. The candle will not burn, since the air has been replaced with carbon dioxid.

CHAPTER V

VENTILATION. ARTIFICIAL RESPIRATION

Ventilation

What Ventilation Does. — Out of doors there is no need for ventilation; the air is constantly stirring even when there is no wind, and the impure air that people exhale is soon carried away, plenty of fresh air taking its place. Indoors, especially when there are a number of people in one room, four things need to be done in order to give every one wholesome air to breathe — notice how they correspond to the four changes that take place in the air while it is in the lungs.

1. Provide a sufficient supply of oxygen.
2. Provide a current of air to take away the waste carbon dioxid.
3. Maintain a proper temperature.
4. Carry off the exhaled moisture.

Record of Open-Air Schools. — The open-air schools, started for pupils who are required by their physicians to live in the open air, winter and summer, have had surprising results. At first it was thought that the pupils could not accomplish much in winter, when they must be very warmly bundled up; but it was found that those children, clumsy as their clothing may sometimes be, could actually do more studying and with less

effort than children who were working comfortably in closed and heated rooms. There were not so many absences on account of headaches and colds, and the pupils did not have those heavy, dull feelings that so often come to indoor pupils at the end of the morning's work. In those schoolrooms, nature is allowed to attend to the first, second, and fourth of the requirements listed above; and proper temperature is secured by wearing clothing so warm that the body heat is easily maintained.

What Happens to the Air Indoors. — Most people live and study in homes and schoolrooms from which the outdoor air must be largely excluded in winter, and in which artificial heat is also required.

We know that if any large amount of breathed air accumulates in a room the odor becomes unpleasant and the effect is unwholesome. Those who are sitting in the room may not notice that the air has become "bad"; but let the pupils go out for recess and if the schoolroom is not properly ventilated, it will seem close when they come in. Such an unpleasant odor in a room means that the air is unwholesome to breathe and will be likely to make those sitting there drowsy and to give them headaches.

How Air Gets "Close." — It is not enough, however, to know that a "close" room is unwholesome; we want to know what makes the air "close." On this point a great many interesting experiments have been made. Persons have been shut up in large, tightly sealed boxes into which air could be pumped at will. It has been found that if care is taken to extract the carbon dioxid from the breathed air, and to put in more oxygen to

take the place of that used in the lungs, a man can comfortably remain in such a box for days; that there are no unpleasant results from being confined in such a box if the air is kept cool and is not allowed to get too moist.

In other tests, people have been kept in small rooms in which they could move around and work comfortably, the rooms being so arranged that the air could be made hot or cold, wet or dry, pure or impure. Many facts have been learned from these tests. It has been shown that to keep the air fresh and sweet, at least four things are needed. The carbon dioxid must be removed; the air must not be allowed to become warm; the air must not be allowed to become too moist or too dry; various dirt or dust particles, which come from people's clothes or elsewhere, must be removed. Each of these requirements may be met in various ways, but the one most readily applied everywhere is to arrange to keep a current of fresh air entering the room and to have it properly warmed. Hence most attempts to ventilate a room aim at supplying it with an abundant amount of outdoor air.

How Rooms Are Ventilated. — The ventilation of large buildings is a scientific and engineering problem which has no place here. What we want to consider is how to keep the air pure and fresh in our homes and in schoolrooms and other assembly rooms where apparatus for ventilation cannot be installed. In such places the problem of ventilation is practically solved if the used air can be caused to pass out, for the excess heat and moisture are then carried off. In an ordinary room, sufficient fresh air will come in around the windows

and doors if there is only some adequate provision for carrying off the used air. Figure 47 shows the direction taken by the air currents. To ventilate a room properly we must therefore provide an exit for the heated air that rises to the top of the room and also for the

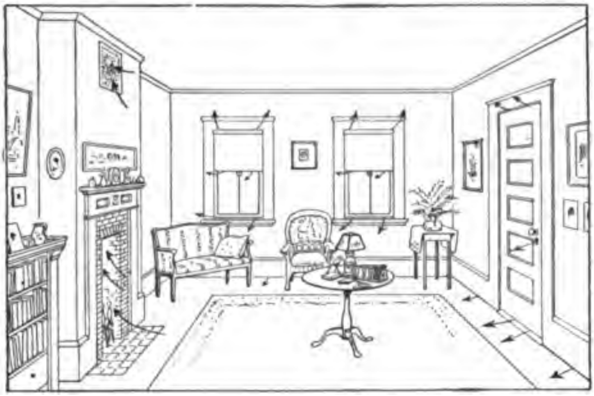


FIG. 47. — AIR CURRENTS IN A ROOM.
The direction of the air currents in an ordinary room are shown by the arrowheads.

heavy air (heavy with carbon dioxid) which tends to sink toward the floor.

In a room occupied by many people, like a schoolroom, the air is used up more rapidly, and frequently cracks around doors and windows do not let the used air out fast enough, and so sufficient fresh air does not come in. Then some other means are necessary. One of two things may be done: either make more of the used air go out, or make the fresh air come in enough faster to force the bad air out.

Usually it is easier to take the second method. One

of the simplest ways of doing this is to raise the lower sash of the windows with a solid board six or eight inches wide fitted close to the window frame. Air will then enter the room through the space between the window sashes, and as it starts upwards it will not fall upon those sitting near the window. A series of holes bored through the board will admit more air if needed, and these may be easily fitted with plugs to fill them when there is intense cold or a high wind.

Heating and Ventilation. — In cold climates it is necessary to heat rooms in winter. Some methods of heating a room help to ventilate it and some make ventilation more difficult. A room heated *with a stove* or a fireplace is easily ventilated, for a burning fire causes a continuous draft up the chimney; this draft removes air from the room, and fresh air always rushes in to replace it. If the stove is allowed to get too hot it makes the room overwarm, and then the people there feel uncomfortable, even though, because of the draft made by the rapidly burning fire, an unusual amount of fresh air is constantly coming into the room. That trouble may be remedied by putting around the stove a jacket (Figure 48) connected by a pipe with the outer air; in this way fresh air will be sucked into the jacket, and thus into the room, fast enough to prevent the room from getting so hot as to be uncomfortable.

In houses *heated by hot-air furnaces* special devices are commonly adopted for supplying fresh air. The furnace is connected with what is called the cold box, which is open to the outdoor air. The air enters this box, passes into the furnace, is there heated, and then hot, fresh

air rises through the flues into the different rooms. Open ventilating flues in the chimney help to get rid of the impure air. Furnace-heated air is apt to be too dry, especially in very cold weather. If there are no evaporating pans in the furnace, some open jars of water standing

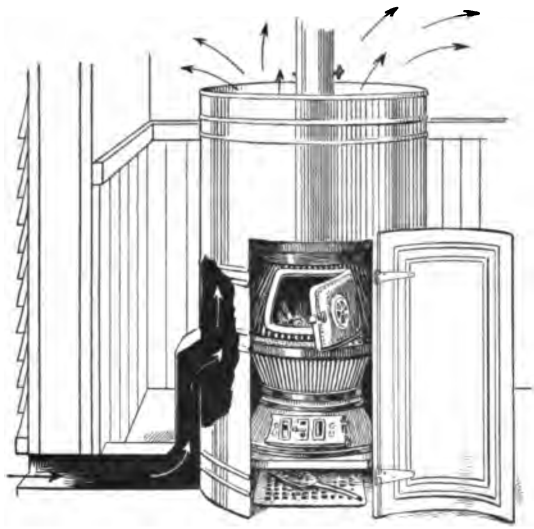


FIG. 48. — A JACKETED STOVE.

A stove with such a jacket around it draws fresh air from the outside and distributes it through the room. The air passes in the direction of the arrowheads.

about the room will make the air more comfortable by increasing the amount of moisture.

In houses *heated by steam radiators* it is not so easy to keep the air pure; for although currents of air move up and down the room, they do not readily pass out. We must then depend upon other means for bringing in fresh air, such as partly open windows, or flues, or fireplaces.

The "closeness" or "stuffiness" of steam-heated rooms may be remedied if we can find some way of keeping the air in motion. On a hot summer day we feel comfortable if there is a breeze, while if the breeze disappears we begin at once to suffer from the heat. Even on a hot day the bicycle rider feels cool as long as he keeps moving but becomes very hot the moment he stops riding. Even an overheated room or one occupied by many people generally feels comfortable if the air can be kept moving, but if the air becomes stagnant, the room is uncomfortable at once.

Comfort in Public Halls. — In a schoolroom or a public hall, where numbers of people are gathered, the air is almost sure to become unfit for breathing unless special means are used to secure good ventilation. It has been discovered that unpleasant feelings may be almost entirely prevented by keeping the temperature down below 65°. Nowadays large school buildings and assembly halls are frequently equipped with special ventilating apparatus, consisting in part of fans that keep the air circulating, and of various appliances for cooling the air and for maintaining the right amount of moisture in it. Remember that there is little danger to well people from cold, fresh air; for every one who suffers from too much cold air there are thousands of people suffering from breathing impure air.

Air in Sleeping Rooms. — There are many people whose work requires them to spend their days indoors, but there is nothing to hinder their spending their nights in air that is fresh and clear. It used to be thought that night air was dangerous for delicate persons; now we know that they are the ones who need most to breathe

clear, invigorating air while they are asleep. A sleeping room out of doors, on a veranda or porch, has brought many an invalid back to health. Those who do not need or desire to sleep out of doors should open their windows at night. In mild weather the windows should be wide open, half way down from the top, half way up from the bottom; in the coldest weather open at least a foot, top and bottom. In summer the windows or the beds should be screened to protect the sleepers from mosquitoes. In winter one's bed should be so placed that the cold air from the window will not fall directly on it; then with plenty of covering one can "sleep warm," breathe good cold air, and wake refreshed. If one goes into a poorly ventilated sleeping room in the morning, he will notice a close "body smell," which shows that there was not sufficient circulation of air during the night; but he will not notice this if the room has been well ventilated.

FIG. 49. — A SLEEPING PORCH.

Dust Our Enemy. — Our lungs were meant for air, not for dust. Every one has seen dust blowing in the streets on a windy day and experienced the discomfort of breathing it. In all our rooms, even when we do not realize it, the air is filled with dust. Did you ever notice how you can follow a ray of light from a crack in a blind, and how easily you can trace it across the room? What you really see are tiny particles of dust floating in the air. This dust is partly living and partly lifeless, the living part being mostly germs, of one kind or another, some of them dangerous, most of them harmless. It is estimated that a quarter of a million people die in this country each year from diseases that affect the respiratory organs and that twice as many are ill of the same diseases. Most of these are germ diseases and some of them come from the dust of the air. This being the case, it is clear that dust is an enemy against which we should continually fight.

Removal of Dust. — Not only should the streets be kept well watered, but our rooms should be properly cared for, living rooms at home and schoolrooms as well. Clearly the dust should be removed from the surfaces where it has settled, and this should be done without stirring it up and getting it into the air again. Sweeping with a broom and dusting furniture with a feather duster throws the dust into the air, from which it only settles back on the chairs, tables, or desks. The best method of sweeping is with a vacuum cleaner, for this sucks the dirt up instead of distributing it. A carpet sweeper is not so good as a vacuum cleaner, but it is better than a broom.

Wood floors should be wiped up with a *damp* cloth or mop, not swept with a broom or covered with water which will take a long time to dry off. An "oil mop" will also pick up the dirt without distributing it. Dusting should be done with a cloth that is damp enough to hold the dust without leaving any moisture on the surface dusted; for polished furniture a good duster may be made by putting a few drops of furniture polish on a soft cloth. A room is well dusted when the dust is taken out of it on the duster, not when the dust is brushed off into the air.

Scientific Dusting. — You may wonder whether the results of dusting and sweeping in this way are worth the extra trouble required; but you could not get any of those who have taken part in schoolroom experiments to doubt it. In some schools pupils have agreed to give this subject a thorough test by taking care of their own schoolrooms in the approved manner; the results reported are conclusive. In one section the number of colds and slight occasional illnesses among the pupils was reduced by 50 per cent. The same improvement could be made in the health of families if dust were regarded as an enemy, harmless as long as it is not disturbed, but so easily roused that great care must be taken in its removal. It is evident why any occupation which keeps one at work in a room constantly filled with dust is classed as a dangerous occupation.

Artificial Respiration

In cases of drowning and of gas poisoning, respiration often ceases before the heart stops beating; it may then

be possible to save life by **artificial respiration**, that is, by having another person work the breathing mechanism until normal respiration can be resumed. When a man has been too long under water, his lungs become filled with water so that even when he is removed from the water he cannot take air into them. To save his life one must first get water out of his lungs as quickly as possible, and then get air into them. By all means send for a physician, and for blankets, if there are others at hand to be sent. *But wait for nothing; go to work.*

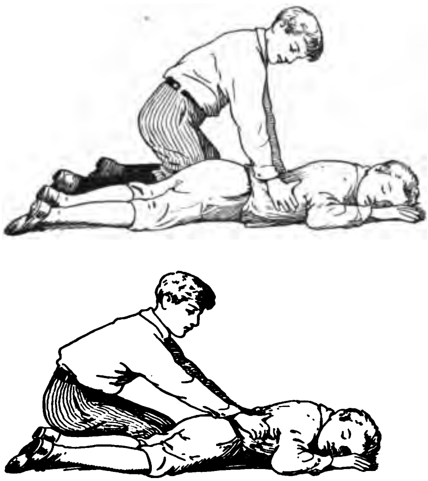


Fig. 50. — The Positions Assumed in Artificial Respiration.

First Aid to the Drowning.—*Work fast; keep cool; don't give up:* these are the watchwords that should govern the effort to bring back to life one who has apparently been drowned. The instant that the drowning man is brought to land (or is taken into the boat), raise the body by the waist, letting the head hang down, so that the water may run out of the mouth and throat. If it does not run out freely, the tongue has fallen back. Another person should then pull it forward; or if there is nobody else near by, lay the body over your knee, head down, catch hold of the tongue

and hold it down, while you shake the body as much as your position will admit. Not more than a minute from the time of leaving the water ought to be used in these operations, for the body is perishing for lack of air.

How to Restore Breathing. — There are several different methods of restoring breathing. One which can easily be carried out without special apparatus is as follows: Place the patient with his back uppermost, and with the head slightly turned to one side. Some object, like a rolled-up coat, should be placed under his shoulders so as to raise them slightly, thus allowing any water that may be left in the lungs to run out of the mouth or the nostrils.

Place yourself to one side of him, as shown in Figure 50, and put your hands, with fingers stretched out, on the small of his back, with your two thumbs near the back bone and the fingers stretched out over the sides, just below the ribs. Throw your weight upon your hands, at the same time pressing upwards a little toward the patient's head. The effect of this sudden pressure will be to force the organs of the abdomen up against the diaphragm and also to push the ribs upward a little. This will squeeze some air out of the patient's lungs: it is an approach to exhalation. Just as soon as you have fully exerted this pressure, quickly release it by throwing your body back enough to remove all pressure upon your hands. The diaphragm and ribs will then assume their former positions, and this will cause a little air to be sucked into the lungs: this is an approach to inhalation.

These two motions should be kept up rhythmically about twenty times a minute, or, if you count rather

slowly, about once every three counts. A second person may help by lifting the patient's arms over his head at the time you relax the pressure, and lowering them when you give the pressure. In it all, remember that what you are trying to do is to *squeeze all possible air out of the lungs when you give the pressure, and then to allow the free expansion of the chest by releasing the pressure.*

Artificial breathing should be kept up for two hours unless natural breathing starts earlier. Stop the artificial breathing every few moments and hold some very light object, like a feather or a thread unraveled from a handkerchief, in front of the patient's nostrils. If the object moves, it indicates natural breathing. Discontinue the artificial breathing just as soon as this occurs. Wrap the person in warm clothing or in blankets, and nature will complete the restoration; it will be an aid if the extremities of the patient are rubbed during the whole process. Persons who have been under water for a quarter of an hour, and even longer, have been brought back to consciousness by such means.

Other Forms of Suffocation. — The same process should be used whenever a person becomes suffocated from any cause whatever. If one has been overcome by smoke or by illuminating gas, artificial respiration is the only means of resuscitating him. A special kind of apparatus called a *pulmotor* is sometimes used for this purpose. If there is one to be had, by all means send for it, but meantime go to work by the method above described.

Gas poisoning differs from suffocation by water in that the gas produces harmful changes within the body —

while the water merely prevents breathing. There is a substance in illuminating gas that is even more attractive than oxygen to the hemoglobin of the red blood corpuscles. So these oxygen carriers take up that substance, thus leaving the body to die for lack of oxygen. Even plenty of fresh air will not arrest the process if it has gone far, because the corpuscles that have taken on this foreign substance are so changed by it that they cannot carry oxygen any more.

QUESTIONS

1. What four things should be provided for in ventilating a room?
2. Is provision made for these four needs in your schoolroom? How? Are they provided for in your home? How?
3. Account for the fact that pupils in outdoor schools can study with less effort than children indoors.
4. What part of a room does breathed air usually occupy?
5. Why is it not the best way to ventilate a room by simply throwing up the lower sash as high as we can?
6. How is a room with a stove better ventilated than a room with a radiator?
7. During what season of the year are we likely to get the least amount of fresh air? Is sickness especially prevalent at this season? Can you see why?
8. What is the usual temperature of your schoolroom? Of your home?
9. Describe a device which will enable one to have a window open on a cold day without causing discomfort to those who sit near it. Could you make a ventilator of this sort?
10. Is a boy who spends most of his play time in a moving-picture theater likely to have as good health as one who spends it out of doors?
11. How many windows has your sleeping room? How much do you open them at night? If you share your room with some one, would you need to open the windows wider than when you have a room to yourself?

12. If the air in a room feels dry, how can you remedy it?

13. Find out, if you can, how bees change the air in their hives when it becomes impure. (Consult an encyclopedia.)

14. Give several reasons why we have to give more attention to the problem of ventilation than did the early settlers in this country.

15. Do you know any families who keep the rooms in which they live at about 80 degrees most of the time in winter? Are the people who live in such homes strong and well, or are they sickly? Explain why.

16. What have you noticed about the air in some of the large department stores in the city? Does your mother often come home with a headache after she has been shopping all day? What do you think is the reason?

17. Which has the more need to open his windows at night, an express driver or a clerk in a store? Why?

18. Mention several occupations that are dangerous because of dust.

19. What is the best way to sweep a room? To dust it?

20. What would you do if you were alone with some one who had been so long under water that he had ceased to breathe? How long would you continue to work over him before you gave up?

21. What would you do if you found some one lying unconscious in a room where the gas was turned on?

CHAPTER VI

SOME OF THE NATION'S UNSEEN FOES

A New Conflict. — There are many stories about the great animal monsters who lived on earth in the early ages. They were so large and so powerful that it seems incredible that the human race, with its primitive weapons, should have survived the conflict with such creatures. To-day, few men are obliged to fight for their lives with ferocious animals; the scene of the warfare has shifted. Mankind has learned how to hold in check the wild animals that are unfriendly to it. New foes have, however, been discovered; and these, as we saw in Chapter 12 (Section I) are much more numerous than the old enemies and even more dangerous than they, because unseen and also unknown to vast numbers of people, who instead of fighting them often ignorantly assist them.

These germ foes of ours are really old residents of the world. Our ancestors suffered from them, but could not fight them because they knew nothing about them. Conditions of life were different then, for people were more scattered; now a large portion of the population is crowded together into cities and towns, and this crowding together makes necessary a vigorous and incessant combat against our tiny unseen enemies.

Germs a National Foe. — The success and the maintenance of a nation depend less upon its laws and its

wealth than upon the integrity, the stamina, and the health of its people. How can a nation succeed if its people do not? What can be hoped for a nation if its citizens are too indifferent, or too careless, to fight vigilantly against foes which in a single year incapacitate a million of its citizens, killing many and making others unable because of illness to do profitable work? Such is the record of the germ enemies that attack the organs of respiration. These germs were not known until the end of the last century; the methods of fighting them are newer still. If every young person who is now in school would do his share to stamp out these enemies, countless lives and much wealth would be saved. It would amount to adding something like half a million people to our population each year. Can you not see that the nation would be greatly strengthened?

There are other germs to fight besides those that attack the respiratory organs, but none that begin to incapacitate so many people; and there is no set of organs, except the heart, upon whose activity we are so constantly dependent. We can live several days without drinking and many days without eating, but we die in a few moments if we cannot breathe. For this reason anything that affects the action of the respiratory organs is serious, and all possible means should be taken to preserve them from injury.

Incubation Time. — After the germs of a disease succeed in getting into one's body, several days pass before they produce any noticeable effect. During this period the forces of the body are battling with the germs trying to drive them out; this period is called the

incubation period. During it the person feels as well as ever; and if the germs are defeated, he may never know that he was attacked by them. The incubation period varies, with different diseases, from three or four days to three or four weeks; for most of the germ diseases it is about two weeks.

Three Minor Diseases. — *Mumps* is not a serious disease. It is usually confined to children and in ordinary cases lasts only a few days. The glands of the cheek and jaws become swollen and painful, making it difficult to swallow. Patients should be kept from school until well and for a few days after. To avoid the disease one must keep away from those who have it.

Tonsillitis is accompanied by sore throat and fever, it usually lasts only a few days, and it is painful though not very serious. The germ that causes it is not known; it is probably carried in the discharges from the mouth and nose. The best way to avoid it is to keep away from those who are ill.

Whooping Cough is a disease whose chief symptom is a violent cough which lasts a number of weeks. It is caused by a germ that lodges in the windpipe and produces a constant irritation which results in the spasmodic cough. The disease is certainly a contagious one, and the germs are in the moisture that is in the mouth and nose, so they are thrown out into the air when the patient coughs. Any one who inhales the air filled with this germ-laden moisture is likely to become infected, and thus the disease passes from person to person. The only protection is to avoid being close to patients while they are coughing. As long as the cough continues the disease

remains contagious. Life in the open air is the best thing for the patient, and for others who wish to avoid the disease. Whooping cough is dangerous for little babies and for old people. People do not commonly have it a second time, although old people occasionally take it, even though they may have had it when children.

Diphtheria. — *Diphtheria* is a much dreaded disease which is usually confined to children. It is caused by a germ (see Figure 25) that grows in the throat. The first evidence of it is usually a sore throat, with white spots on the tonsils. These spots spread until a membrane is formed which grows down into the throat and occasionally shuts off the breathing. Ordinarily, however, the danger is not from the membrane itself, but from a poison that is made by the diphtheria germs as they grow. The poison is absorbed through the walls of the throat into the patient's blood; then the fight begins.

The poison that the germ makes is called a **toxin**. The body, when attacked by the diphtheria toxin, makes a substance called an **antitoxin** that neutralizes the effect of the poison. If the body can make this antitoxin faster than the germs produce the toxin, the patient will probably live. To assist the body, physicians now administer a form of antitoxin that is produced in the blood of specially selected horses. If this is given very early in the disease before the poison has weakened the system, the patient has an excellent chance of recovery; for if the poison is neutralized, the body can drive off the germs. Since it is so important that the antitoxin should do its work early, cases of sore throat in young people should be inspected by a physician, especially if there are white patches.

How Diphtheria Is Spread. — It has been said that the milder the case of diphtheria is, the more danger it offers to everybody except the patient. That is because a mild case is less likely to be regarded as serious and fewer precautions are apt to be taken. In fact, the body is so well able, in some cases, to neutralize the disease that the patient may think he has only a cold, and take no precautions at all against infecting others. Yet the germs from such a very mild case may be carried to other people and produce in them the most serious form of the disease, because they are not good antitoxin makers.

When the disease is recognized, the patient should be *isolated,* either at home or in a hospital, and no one should see him except the doctor and the nurses. He must be kept away from others as long as the dangerous germs are still alive in his throat, which is usually two or three weeks after his recovery. The germs adhere so loosely to the walls of the throat that they are easily detached. They get into the saliva, and will be sure to be left upon anything that the patient may have in his mouth: his fingers, pencils, drinking cup, knife, fork, spoon, etc. Another person using the same pencil or drinking cup may get the germs in his mouth, and so may "catch" the disease. Thus these germs may be carried from person to person in a family or in a school, especially as they remain alive for several days after leaving the mouth. Diphtheria patients should use, so far as possible, articles that may be rendered safe and free from germs by boiling for ten minutes.

Precautions against Diphtheria. — It is a wise rule never to put into the mouth anything that another has had in

his mouth, and to keep away from persons who have sore throats. Sometimes a person who is perfectly well has the germs in his throat, and although they are not injuring him because he is for some reason *immune* against the disease, he might be the means of giving this dreaded disease to his schoolmates. For this reason the school nurse or doctor occasionally makes an examination of the throats of all the children in a school to see whether any one of the well children has the germs in his throat. Such a person would be called a **bacillus carrier.** If there are any such carriers found, they are kept out of school for a few days, until it can be shown that the dangerous germs have disappeared from their throats. Sometimes a pupil's parents fail to understand why he has been sent home from school by the health officer when he is not ill; the reason is because he may be a source of danger to his companions.

Colds. — The more or less slight indisposition that is called a "cold" is badly named; it leads many to think that colds come from being cold, from staying out in the cold. The fact is that if the name were used only for trouble so caused most of us would never have a single "cold" as long as we lived. A cold is really an *inflammation* of the nose, throat, windpipe, or lungs. Inflammation means an enlargement of the blood vessels, and when that occurs in the air passages their linings become very sensitive. Usually a large amount of liquid is secreted and runs out from the nostrils or down into the throat. If the inflammation is only in the nose and throat, we call it a "cold in the head"; if it extends further down, into the bronchi or the lungs, it is called

bronchitis. If a cold gets down into the lungs, it is best to have the advice of a physician to prevent more serious trouble.

A cold in the head is uncomfortable but in itself it is commonly of no great importance, for it will disappear in a few days. It may, nevertheless, do much harm by producing just the conditions that are favorable for the germs that cause **bronchitis** or **pneumonia.**

The cause of a cold is probably the multiplying of some of the germs that are usually in the mouth and nose waiting a chance to grow. Why is it, if they are always there, that they cause a cold at one time and not at another? One of the ways in which we help them is by living in warm rooms and bundling up our necks and faces when we go out on a cold day. People who live out of doors, like soldiers and sailors, do not have colds, these troubles being confined almost entirely to those who live indoors. Living in warm rooms and wrapping oneself too warmly tends to weaken the throat until it cannot endure cold air.

The way to avoid colds is to live as much as possible in the open; to sleep with windows open even in winter; to take cold baths; and to avoid overcrowded rooms, like cheap moving-picture shows. One person may catch a cold from another, and it is best therefore not to stay close by a person who has a cold. If those who have colds were thoroughly considerate, they would neither cough nor breathe in the faces of others, and would see that boiling water is poured on their handkerchiefs before sending them to be washed. They would never dry a handkerchief in the air or on a radiator,

without washing, for that is very liable to spread the germs.

The Grip or Influenza. — *The grip* is much more serious than a cold, which it often resembles at the start; sometimes the effects of it last for weeks. The grip is certainly contagious, and the germs that cause it are sure to be in the **sputum** (matter coughed up) and in the discharges from the nose of the patient. The same precautions should therefore be taken as with the sputum of consumptives. Where possible the patient should be isolated from others, especially from elderly people who are most likely to take the disease and with whom it is most dangerous. The grip prepares the way for pneumonia by decreasing a person's resistance to the pneumonia germ. We know of no means of preventing it, except to avoid being with those who are ill with the disease and to keep up the general health.

Pneumonia. — It has long been supposed that **pneumonia**, which is a very serious disease of the lungs, came from a "bad cold." Old people used to say, "If you do not take care of that cold you will have pneumonia." That seemed foolish when it was discovered that pneumonia is caused by a germ. But there was good sense, after all, in the old people's saying, for the pneumonia germs are widely distributed; we are continually encountering them, and they are often found in the mouths of well people, doing them no injury at all when their lungs are sound. If the lungs become inflamed by a "cold on the lungs," the pneumonia germs may then get a chance to enter at the inflamed places, thus causing the disease. For this

reason a cold in the chest should be given particular attention.

Though it is slightly contagious, there is little danger of taking pneumonia if people are not allowed to come into too close contact with the patient, especially if the sputum is burned or disinfected. The need of fresh air is greater in pneumonia than in any other disease. Sometimes pneumonia patients are treated in the open air or given pure oxygen to breathe.

Tuberculosis — The Worst Foe

The Tubercle Bacillus. — There is a slender disease germ, called **tubercle bacillus**, that causes more deaths in our country than anything else (see Figure 51). If

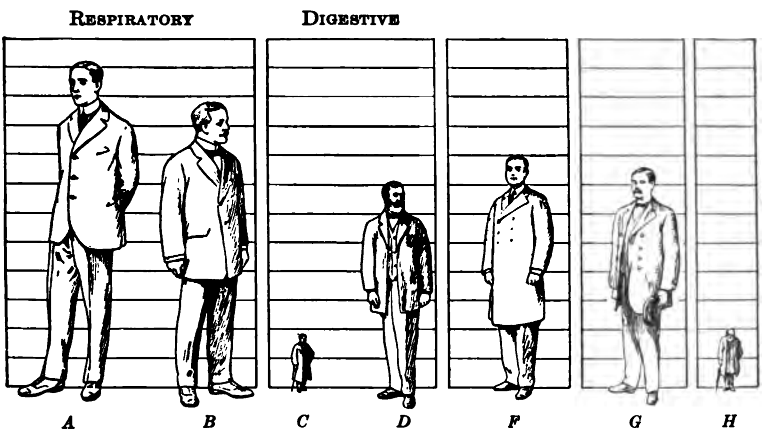


FIG. 51. — COMPARATIVE NUMBERS OF DEATHS FROM VARIOUS DISEASES.

The numbers of deaths from the diseases mentioned are proportional to the height of the figures. *A*, tuberculosis; *B*, pneumonia; *C*, typhoid fever; *D*, other intestinal diseases; *F*, heart diseases; *G*, accidents of all kinds; *H*, old age.

we could kill these germs, we could get rid of the disease they produce. They grow only in the bodies of men and a few animals, and they cannot live more than a year or two outside the body. Hence, if every one who has the disease to-day could make certain that he did not let any of the germs escape to injure others, there would be no more new cases except those started from the germs already spread abroad, and those could not be dangerous for more than two years. So after two years there would be no new cases at all, and this would mean that in our country alone 175,000 deaths from the disease would be saved every year, and more than $300,000,000.

What Tuberculosis Is. — The disease caused by the tubercle bacillus is called **tuberculosis.** The bacillus may grow in practically any part of the body. Among children, it may attack the hip bone, causing **hip disease**; in the lymphatic glands, it used to be called **scrofula**; in the lungs, it is called tuberculosis of the lungs, or **consumption** — and this is the form in which it is most common. Physicians now know (1) how tuberculosis is acquired; (2) how it may be prevented; (3) how most forms of it may be cured. Yet with all this knowledge they cannot begin to fight the disease as they might, because many people *will not believe* that this unseen enemy is really dangerous until it attacks some one of their own circle. If we could see every living tubercle bacillus around us as a tiny soldier with a gun, we should probably be much frightened by their number, and much encouraged, at the same time, to see how readily they can be slain.

How Tuberculosis Is Acquired. — There is only one way in which tuberculosis is ever acquired — through taking into the body from the outside the bacillus that produces the disease.

Not Inherited. — It used to be thought, before the bacillus was discovered, that certain families were "fated" to die of tuberculosis. If the parents had it, the children were expected to have it; they were supposed to inherit it from the parents, just as they inherited eyes of a certain color. Now it is known that this is not the case; the germ cannot pass in this way from parents to children. Children do not "inherit" bad grammar, they pick it up from the conversation that they hear day by day. In the same way children may take tuberculosis from some member of the family, or they may be guarded against the bacillus so that they need never have the disease.

Germs Ever Present. — In parts of the world where men do not live, the bacillus is not found, but wherever men live it exists in large numbers. It goes floating about in the air we breathe, alive but not active. The germ is a hardy one, for cold does not harm it, and it may survive much heat, though a moment's boiling will kill it. To produce the disease the germ must usually find entrance by the mouth or nose. When it can get a chance to grow it multiplies rapidly, by the simple method of growing and then dividing, and it is one of the most difficult foes that the body has to fight. When the body disposes of bacilli in the lungs, there is left, at the spot where the conflict took place, a sign of it which the doctors call a *scar*. Such scars have been found in the

lungs of many people who never had the disease and never even knew that they were threatened with it; but the scar tells the story, and shows that the body at one time fought and overcame the invading foe.

Germs in Dust. — Outside the body the bacillus can last longest in damp, filthy places. Sunshine and fresh air are its foes, but it is well pleased with a dust heap; there the germs may be gradually reduced to a powder, and then every gust of wind that blows over the heap of dirt may carry them into the air which the passerby has to breathe. We can take many precautions in regard to our food, since we can choose what we eat and how it shall be prepared; but we cannot filter the air we breathe, or put it through any other process that shall remove the germs.

Fortunately for us, after the germs have become dry and have been out doors in the sun for a while they become harmless. Yet there are about 10,000,000 people in this country to-day who will finally die of this disease unless our fight against it becomes more vigorous than it has been. The sad thing about it is that nearly every one of these deaths could be prevented if people would only use proper precautions.

How Consumptives Spread the Disease. — If the disease is in the lungs, the patient is constantly coughing up matter which contains large numbers of the bacilli. These can be made harmless by proper care, but if the sputum, laden with deadly germs, is allowed to soil the hands or clothes of the patient, or if it is allowed to dry upon articles used by him, or on the floor, so becoming powdered and mingled with the dust, any one who comes into the

room may breathe in the germs or may get them on his hands and so into his mouth. The room of a careless consumptive is thus a danger spot.

On the other hand, the consumptive is not a source of danger if he is careful in his habits. His breath does not contain the germs, though when he coughs or sneezes tiny drops of sputum which are laden with germs may be blown out of his mouth. If he holds a handkerchief before his mouth when he coughs or sneezes, these will be caught in the handkerchief; but if he coughs them into the air, they will float around for some distance and be a danger to people about him. To shun a careful consumptive who faithfully follows the precautions given on page 182 would be as foolish as to refuse to ride in a carefully inspected elevator because you know that badly constructed elevators sometimes break down and kill their passengers. There is probably no place in which there is so little danger of acquiring consumption as in a sanitarium where consumptive patients are cared for, since all the many patients there know how to guard their sputum; while one of the most dangerous places is the room of a consumptive who pays no attention to the matter.

How Tuberculosis May Be Prevented. — Evidently the only way to stamp out tuberculosis is to kill all the bacteria that cause it. Whether this will ever be done we cannot say, but it will surely take years. Meantime, there are several things that every one ought to do to guard himself against acquiring the disease.

1. *Guarding against the Bacilli.* — It is not wise to go among careless consumptives unless duty takes us there,

and then we have the right to try to persuade them to take proper precautions. Nor is it wise to go habitually to places where people spit on the floors or walls. It is better to stay away, even if there is no one present whom you know to be a consumptive. Some rooms occupied by careless consumptives become so badly infected with the germs that any one who goes to live in them is exposed to constant danger.

Those who move into a house or apartment that has been occupied by others ought to make inquiries about the previous tenants. If they cannot get satisfactory information, then the safe thing is to make all the rooms sanitary, since the tubercle bacillus may live a couple of years in dark, damp places, or in undisturbed corners. So all the walls should be cleaned, repapered if possible, or carefully scrubbed with a dry mop if new paper cannot be had; the woodwork should be repainted or thoroughly scoured; the floors and every nook and cranny that may contain dust should be scrubbed with a chloride of lime mixture (one part lime and twelve parts water). Then, with a safe, clean house in which to live, the family should observe in sweeping and dusting the precautions already suggested against raising the dust that is continually entering our rooms.

2. *The Power to Resist the Bacilli.* — If our bodies are kept in good condition they have great power of resisting the attacks of the bacilli, which do not thrive in vigorous, healthy tissue. The athlete guards himself against all sorts of minor ailments, like colds and indigestion, because he wants to be in the best possible condition for the contest before him. If each one of us in his own

way were to use equal care about keeping himself constantly in condition to resist the body's foes, we should not have much occasion to fear their attacks; this again means observing the rules of health already given, and avoiding the use of alcohol. There is also one particular thing we can do to keep the lungs themselves in good condition. By increasing the lung capacity and keeping all parts of the lungs active, as has been suggested, we do much to guard against their becoming the lodging place for the bacilli.

The Cure of Consumption. — Fortunately consumption can be cured, but curing it is like stopping a leak in a dike — the earlier you start, the better chance you have. Many people waste precious months trying to deceive themselves into believing that they "have a bad cold" or "a bad throat," instead of meeting the situation squarely and starting the fight when all the chances are in their favor. Every one who has a persistent cough ought to consult his doctor as to the cause of it, and the cure.

Consumption is not cured by taking medicine. None of the many remedies that are advertised as "cures" should be taken. Most of them contain alcohol in some form, and alcohol is almost certain to make the disease worse. Remember, nothing that can be put into a bottle will stop the work of the bacillus and make the consumptive well again.

Patients frequently go away from home into a different climate; but a change of climate is not the first requisite for a cure. Before doctors knew how to cure the disease, change of climate was usually advised; now

it is considered desirable only when the patient can easily afford to remain idle for some length of time and can also afford to meet the heavy expense of life away from home. Change of climate is much less important than *air, sun, food, and rest;* those are the only known cures for consumption. The principle on which they work is to reënforce the body in its attempts to resist the disease.

Fig. 52. — A Sun Parlor Designed for Tuberculosis Patients.

Fresh Air and Sunlight. — Night and day, summer and winter, the patient needs all the fresh air possible, and he does not need to have out-of-doors made over for him. Ordinary winds and currents of air are not injurious to him, for he must be so warmly clothed as to protect himself against being chilly. He will be amazed to find that cold air is good for his sick lungs. One of the advantages of open-air sanatoria is that the patients learn from each other how to live out of doors and to consider cold air their best friend.

The consumptive is fortunate if he can stay at home and live in a well-ventilated tent or on a veranda (see Figure 49) that can be curtained to protect him from driving storms. He should sleep out of doors, and if he

is not at work should count as lost every moment spent indoors, away from the sunshine which is an important part of his cure. One will save on doctor's bills what he spends on sleeping porches. Keep the windows open and the pill box stays shut. If the air and sunshine could penetrate into the diseased tissues they would soon kill the germs; as they cannot, the best thing is to get all possible benefit from them. When cases of tuberculosis are taken in time, the patient can usually be cured in his own home.

Tissue-building Food. — The tubercle bacilli destroy the tissues of the body. But if the tissues can be built up faster than the bacilli break them down, the patient will recover. So he must have as much food of the right kind as his body can take care of. He needs milk and eggs in as large quantities as he can digest them; they should come between his meals (he is an exception to the rule in this respect) and should not prevent his eating three regular meals, consisting of meat and any other forms of proteid that he can digest, vegetables, and fruit. It is not wise for him to eat more of the fuel foods than may be needed to keep the body warm and to give the needed energy. Being in the open air will help him to relish extra food.

Rest and Exercise. — In cases of consumption that are taken in hand at the start, the patient may be able to do his regular work, with safety to himself and to others. When cases have progressed further, it is of prime importance that the patient should have much rest, keeping quiet most of the day, doing absolutely nothing, so that all his force may be spent in combating the disease.

If he can take a little light exercise without tiring him or greatly increasing his rate of breathing, that will be useful, but it should be carefully watched, and decreased or increased as his progress warrants. The exercise should, however, be only a break in the periods of rest.

The Consumptive Can Protect Others. — Every careful consumptive should be honored as a public-spirited citizen; the nation owes him its thanks if he is faithful in guarding those about him from the disease. In addition to the following general suggestions every consumptive ought to have simple directions about various details of his life. The Charity Organization Society of New York City issues an excellent circular which it sends free on request.

1. The consumptive's first care must be the destruction of the disease-laden sputum. It should never be swallowed, but should either be coughed into paper napkins which can be burned, or into cups containing a weak solution of carbolic acid (five teaspoonfuls to a pint of water); the paper cups are best because they can be burned with their contents.

2. The hands and mouth should be washed frequently in warm water and soap.

3. In coughing or sneezing, care should be taken to cover the mouth and nose with a paper napkin, so that none of the spray which carries germs may get into the air. The napkin should be promptly burned. If a paper napkin is not at hand, a handkerchief or piece of cloth may be used, but this should afterwards be placed in boiling water for a few moments, if it is too valuable to burn.

4. The consumptive should sleep alone, and both his body clothes and his bed linen should be washed separately from other clothes; they should not be allowed to stand around, but should be placed in water until ready for washing.

Alcohol and Tuberculosis. — Statistics show that there is a larger proportion of tuberculosis cases among those who take alcoholic drinks than among non-drinkers. Alcohol not only makes conditions favorable to the bacillus but it is harmful in the cure of consumption. The great need is to have the digestion in the best possible condition, and the lungs actively engaged in the purifying of the blood, so that the patient may take as much nourishment as possible in order to build up the tissues and to counteract the power of the bacteria. Both the stomach and lungs are unfavorably affected by the use of alcohol.

Tobacco, also, is bad for consumptives, and for those predisposed to the disease, as it tends to weaken the heart and thus to obstruct the circulation, making it more difficult for the lungs to resist attack.

Animal Tuberculosis. — When it was discovered that other animals beside man are subject to tuberculosis, it was greatly feared that human beings might be acquiring the disease from them, especially from the meat and the milk of diseased cattle. Long and extensive study has proved that there is no danger from cooked meat or pasteurized milk. Ordinary market milk cannot safely be given *raw* to babies and children, for it has been demonstrated that raw milk from tuberculous cows may produce tuberculosis among children. Since there are

now many cows which have this disease, and since their milk is likely to be a part of the supply furnished to any city, it is not safe to give the ordinary market milk to children unless we can be sure that it has been properly pasteurized.

Some Results of the Struggle. — Communities have been carrying on a determined warfare against this disease since 1875, or thereabouts, and the results of this combat have been surprisingly happy. In 1865 the deaths from this disease were about 40 per year for each 10,000 people; fifty years later the mortality had dropped in some places to 15 per 10,000, in others to 20. This means that in 1865 one-quarter of the deaths were caused by tuberculosis, while now less than one-seventh of them are so caused. Although about 175,000 people still die of it each year in the United States, more than 300,000 would die each year were it not for the precautions that are now being taken; that is, there are at least 150,000 people in our country who would have died of tuberculosis during the last twelve months, had we not adopted methods of checking the spread of the disease. It means that the fight against it is saving the life of one person every three minutes, day and night.

QUESTIONS

1. Why are germs more dangerous than wild animals?
2. What conditions of modern life tend to make certain germ diseases a greater menace than they were a century or two ago?
3. What precautions should one take to avoid contracting such diseases as mumps, whooping cough, or tonsillitis? Have you ever heard of serious consequences resulting from one of these diseases?
4. Find out how antitoxin is prepared.

5. The Board of Health of a certain city in which there was a severe epidemic of grip issued warnings cautioning people to avoid crowded halls and theaters and crowded street cars, not to use public telephones, and to get plenty of sleep. Was this good advice? Why do you think so?

6. Why should one never drink from a cup that another has used until it has been sterilized in some way, even though the person using it was apparently perfectly clean and healthy?

7. Is a Maine lumberman likely to have frequent colds? How about a clerk in a store? What can the clerk do to avoid them?

8. Why is it unwise to neglect a severe cold?

9. What are some of the forms which tuberculosis takes? Which is the most common? How is tuberculosis acquired?

10. If tuberculosis is never inherited, how do you account for the fact that children of a tubercular parent often are very likely to have the disease?

11. Does your city have a law against spitting in public places? Do you think it is important to have such a law? Do you consider that it is well enforced?

12. What precautions should a tubercular patient take in order not to be a danger to others?

13. Is there any medicine that will cure consumption? What is the only treatment to which it will respond?

14. Can you give any reason why persons living in dark, damp rooms are more likely to have consumption than those living in sunny ones?

15. Write a theme on ways and means of stamping out tuberculosis in your community.

CHAPTER VII

HOW THE BODY IS MADE MOVABLE

How the Muscles Work

The Need for Motion. — Plants use most of their food for growth; animals use most of their food for motion and a comparatively small amount for growth. There are some parts of the body, like the upper jaw, that are not made to move, but in most parts motion is possible. Traveling from one place to another, holding and carrying things, eating and talking, are all dependent upon motion. It is by slight changes of "expression," made by motions of different parts of the face, that one can tell whether a friend is gay or unhappy, pleased or displeased. Motion of all kinds is made possible by the muscles.

How Motion Is Produced. — Motion in the body is always produced by **muscles**; at the same time they could not give motion without the combined aid of the *bones* and the *nervous system.* No matter how strong a man's muscles may be, without bones he could not even sit in a chair; however powerful his arm muscles, he could not even lift a pin if the muscles had no hand bones to pull against.

A muscle will not pull a bone without receiving orders to do so; it gets its orders from the nervous system. In

this section we shall consider the part played by the muscles and the bones without making reference to what is done by the nervous system; but the pupil should always keep in mind the fact that no muscle acts of itself. Every muscular action is started at the direction of some part of the nervous system.

The Action of Muscles and Tendons. — A grown man ought to weigh from two to two and one-half pounds for every inch of height. His muscles constitute about half his weight; they form what is called the "flesh" (not the fat) of the body. We seldom see the shapes of

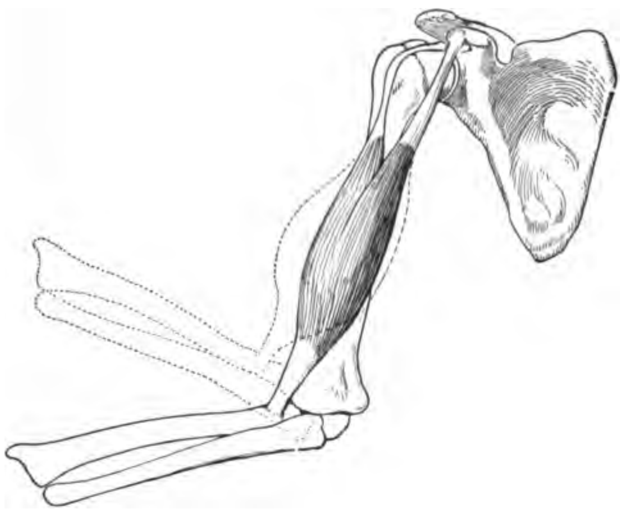


Fig. 53. — The Biceps Muscle and Its Attachments. Showing the method of moving the arm, the dotted line indicating the position when the biceps contracts.

the muscles because they are overlaid with fat and skin. One of the easiest to observe is the biceps muscle of the

arm. Test it by placing the right hand on the biceps of the left arm. When you move the left forearm up and down you can feel that the biceps muscle is largest in the middle. Figure 53 shows how the ends of that muscle taper, and that those ends are attached to the bones by firm white bands, called **tendons.**

FIG. 54. — MUSCLES OF THE FOREARM. *A.l.*, the annular ligament, holding the tendons in position.

A *tendon* is not made of muscle; it does not expand and contract as all muscles do, and it cannot be stretched. The function of the tendons is to transmit the pull of the muscle to the bone which the muscle moves, just as the tugs of a harness transmit the horse's pull to the wagon. The tendons are of different lengths; some are very short, some are long like those which extend from the arm to the fingers and from the leg to the toes.

Figure 54 shows the arrangement of the muscles and tendons of the left hand and arm. Muscles are not necessarily near the bone they move, as you can see by feeling how they work in your own arm. With the right hand grasp the left arm just below the elbow, then clench the fingers of the left hand and open them; the motion of the fingers is produced by muscles in the arm, and you can see how tightly the tendons stretch on the inside of the wrist as the fist is clenched. If the muscles that move the fingers did not have those long tendons but had to extend down

through the wrist to the fingers, how unshapely they would make the wrist and the hands.

See what a long pull there is on those finger tendons. One end of the tendon is attached to a finger bone and the other end to a muscle up in the arm. When the muscles contract, the long tendons might bulge out near the wrist, if it were not for the firm band that goes around them and straps them down just enough to keep them in place and not enough to interfere with their working easily. That band shows in Figure 54. There are similar bands serving the same purpose in other parts of the body.

FIG. 55. — THE MUSCLES OF THE BODY.

Muscles Differently Controlled. — While the motion of all muscles is directed by the brain, the directions are given in two different ways; and the muscles are classified according to the way in which they receive their directions. (1) The **voluntary muscles** are under the control of the will; the brain gives them orders when we wish them to move. The muscles of the

hands and feet are voluntary muscles. (2) The **involuntary muscles** are not controlled by the will, and usually we are neither aware of what they are doing nor of the fact that the brain is giving them any orders. The muscles of the stomach are involuntary.

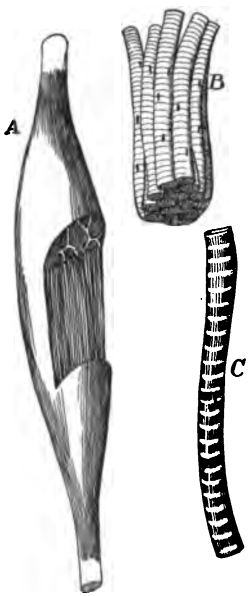
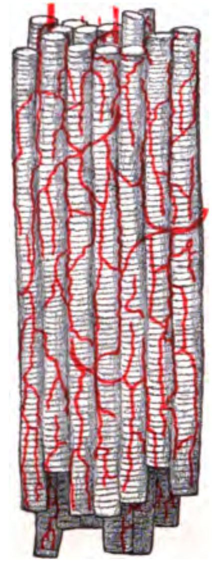


FIG. 56. — A MUSCLE.
A, the whole muscle, with tendons at the end, showing its division into bundles; *B*, one of the bundles of muscle fibers; *C*, a single muscle fiber.

Voluntary Muscles. — There are about 500 voluntary muscles; each one of them has been named, but we are more interested here in the way they work than in their names. They are of various sizes and shapes, as is shown in Figures 54 and 55. Each of those muscles pulls in the direction in which the lines in the figure are drawn.

A muscle seems to be a solid mass, but looked at under a microscope it proves to be made up of an immense number of threads called **muscle fibers.** Figure 56 shows the arrangement of these fibers and shows that they are striped. The fibers run lengthwise of the muscle. They are bound together into little bundles; even the smallest muscle contains a number of bundles. The binding substance that holds the muscles together so firmly is called **connective tissue,** a name that is easily explained when one knows that this tissue is found all over the body, connecting all

THE CHIEF ARTERIES AND VEINS OF THE ARM AND HAND
The dark red veins are nearer the surface than the bright red arteries.



MUSCLE FIBERS WITH THE CAPILLARIES RUNNING UPON THEM WHICH NOURISH THE FIBERS

the different parts and helping to hold each one in its place.

Minute capillaries run among the muscle fibers, as shown in the opposite colored illustration. Through the thin walls of those capillaries the fibers take from the blood the material they need (1) to furnish energy with which to do their work, and (2) for building new muscle fiber. Through the muscle bundles there also run **nerve fibers** by which messages come from the brain, which controls the action of the muscle. Each muscle has its own specific work to do. For instance, the muscles that bend the arm have no other work to do than to bend it; they do not even straighten the arm, that being the work of another set of muscles. In the arm and hand there are over fifty different muscles, by which it may be moved in as many different ways.

Involuntary Muscles. — When a boy decides to train his muscles, to make them strong and supple, he never thinks of the vast number of involuntary muscles that help to form the walls of most of the tubes of the body, like the stomach, the intestines, the arteries; nor does he need to, for they get sufficient exercise in doing their daily work. To be sure they are more sluggish than the voluntary muscles, do not respond as quickly to the orders given them; but they work for long hours at a time, and some of them remain contracted for a long time, in a way that none of the voluntary muscles can imitate. They churn the food in the stomach and drive it along through the intestines, they pump the blood from the heart to all parts of the body, control the flow of blood in the blood vessels, and do a great deal of other work on which the

life of our bodies is absolutely dependent. In that respect they are even more important than the voluntary muscles; but since they are not under the control of our wills we cannot give them direct help in doing their work, so we have less need to know about them than about the other muscles. In appearance they are very different from the striped (voluntary) muscles; they are made up of unstriped fibers, which are bound together into flat masses.

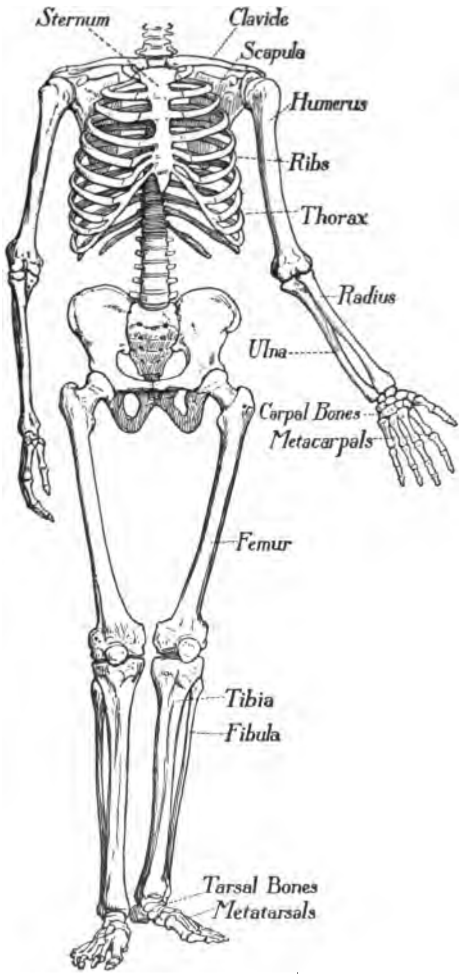


Fig. 57. — The Human Skeleton.

What the Bones Do

Why Bones Are Needed. — The voluntary muscles would be of no use to us if they were not attached to the bony framework of the body. It is necessary to know

more about the **bones** before considering how the muscles act, since both of them are involved in every motion we make. An adult has about 200 bones, a child has more than 200; some of them unite as he grows. The bones, when taken together, are called the **skeleton**. Figure 57 shows the entire skeleton with the exception of the 28 bones that form the skull. (For the skull, see Figure 59.) As a picture, the skeleton is not attractive, but it grows very interesting when one remembers how much is done for the rest of the body by that gaunt bony framework.

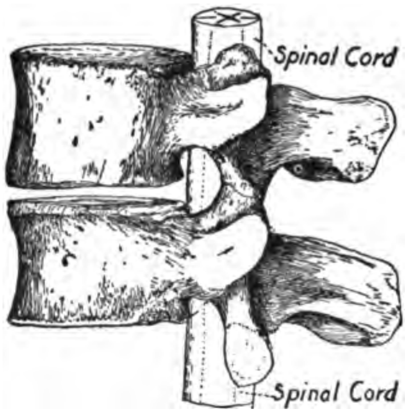


FIG. 58. — TWO VERTEBRÆ.
The spinal cord extends through them.

1. The bones protect delicate organs, like the heart and lungs.

2. They support the soft and flexible parts of the body.

3. They make motion possible by giving muscles the resistance and the leverage they need.

Location and Use of the Principal Bones. — The spinal column, which is in the middle of the back, is a strong support for the whole body; it consists of a series of small bones which are wonderfully fitted together and are capable of slight motion. In a grown person the spinal column or backbone is about 28 inches long. Each one of the bones that make up the column is called a **vertebra** (plural **vertebræ**). Figure 58 shows two of

them. Notice the sharp-pointed bones that appear at the right side of that figure; they are what we feel when we run our fingers down our backs. The rounded surfaces of the vertebræ are on the inner side of the spinal column. See how carefully the vertebræ protect the delicate **spinal cord** that runs through the bony channel they make for it.

An animal that has a spinal column is called **a vertebrate.** Vertebrates include the four-footed animals with which we are familiar, as well as the birds, the reptiles, and the fishes. All of them have, like man, a much greater power of motion than would be possible if the long spinal column were made up of one solid bone, which would necessarily be so stiff that it would be easily broken. The leg bones are not nearly as long as the backbone, but they frequently get broken, while we rarely hear of a break in the many-pieced backbone.

FIG. 59. — THE HUMAN SKULL.

The skull, a rounded bony box that rests on the spinal column, is shown in Figure 59; it has to protect some of the most important parts of the body — the brain, the eyes, the ears, and the organs of taste and of smell. Notice how few openings there are into the skull, and how carefully they are placed.

The chest is another larger and much more flexible box of bone; it is made up of the breast bone (the **sternum**) in front, the **ribs** on the top and sides, the spinal column on the back. When we breathe, this chest must move, and if it were practically solid like the skull, it would not answer its purpose at all. Instead, it has twelve pairs of slightly movable ribs, all attached to the backbone, and all except the two lowest ones attached to the breast bone. Those two, being fastened only at the back, are called *floating ribs.* The heart and the lungs are securely protected inside the ribs, which also give protection to portions of the stomach and liver.

The strong bones at the hips form the *pelvic girdle,* a partial box which gives support to the organs in the lower part of the trunk.

The *arms* and *legs* are much alike in their bony structure; each of them has three bones, the longest and the strongest single bones in the body; they are constantly in motion, and they have to be strong enough to bear great strains. One of the bones that is often broken by a fall on the point of the shoulder is called the *collar bone* (**clavicle**). Notice in Figure 57 how it stands up above the rest of the chest bones; it is easy to see why it gets broken.

QUESTIONS

1. Tell one important way in which men and animals differ from plants.
2. What causes a muscle to move? A bone?
3. Of what are muscles composed? To what are they attached?
4. How does a tendon differ from a muscle?
5. Why are there so many tendons at the wrist?

6. How does the blood needed to nourish a muscle enter the muscle?

7. Are there any muscles that do not move bones? If so, what ones? Are there any that are both voluntary and involuntary? If so, can you name some?

8. Why does a baby have to *learn* to walk? Why does a little child have trouble in handling his spoon and fork?

9. What happens to a muscle when you do not use it at all? When you use it too much? What happens when you develop one set of muscles more than another?

10. If the muscles below your elbow should be paralyzed, what motions would you lose?

11. When you close your hand, do you use the same muscles that you used when you opened it?

12. Can your father run as far and as fast as you can? Can he jump as far? If not, why not?

13. What muscles are specially exercised when playing tennis? When playing basket-ball? When skating? When swimming?

14. If one of your muscles had to be interfered with and you had your choice, which would you choose — a voluntary or an involuntary muscle? Why?

15. How many bones are there in your body? How many can you name and locate?

16. What bones protect the skull? The lungs? The heart? What bones support the stomach and abdomen? What bones enable us to walk? To throw a ball?

17. How many openings are there in the skull? What purpose do they serve?

CHAPTER VIII

BONES AND JOINTS

Bone Structure. — The different bones have a variety of work to do; all of them are made as *light* as is consistent with the amount of *strength* their work requires. The long bones are hollow tubes, which makes them much stronger than the same amount of material would be if formed into a solid cylinder. Following the pattern of these bones, hollow tubes are now used at many points in bicycles, automobiles, and flying machines. The longest bone is that of the upper part of the leg (the *femur*). Figure 60 shows it cut open, with its large, solid but spongy ends and the long, hollow shaft. In order that there be no waste space, the hollow shaft is filled with marrow in which the red corpuscles are made. Men have never discovered any way in which to get more strength in proportion to the weight than is given by the structure of these bones.

The expression " dry as a bone " represents the notion many people have of the bones; but the fact is that they are alive, not dead and dry. To keep them alive and well there are tiny blood vessels that run into them through small holes. All bones have nerve connections; the nerves in the teeth which make them ache also serve a very good purpose.

Bone Materials. — Bones are made up of *animal* matter, which gives them strength, and of hard, brittle *mineral* matter, which gives them stiffness. In the living bone the two are mixed together and form one substance, which is about two-thirds mineral and one-third animal matter. If a bone is put on a hot coal fire and left there for half an hour, the *animal* matter will be burned out, leaving only the mineral matter which is lime and will not burn. This burned bone will keep its original shape, but it will be light, and so brittle that it can be crumbled in the fingers.

FIG. 60. — THE FEMUR CUT LENGTHWISE.

Showing the hollow shaft and the spongy end.

It takes longer to remove the *mineral* matter; this is done by putting a bone into a dish of dilute nitric acid. In a few days the acid will have dissolved out the mineral matter leaving only the animal matter. The bone will appear unaltered in size or shape, but it will be so soft and flexible that it can be bent readily.

FIG. 61. — A BONE FROM WHICH THE MINERAL MATTER HAS BEEN REMOVED.

Showing its flexibility.

The Baby's Bones. — The bones of a baby contain much more animal matter than those of a grown man,

so they are much more easily bent. The result is that the baby seldom gets a broken bone, even from a serious fall. Those pliable bones have one disadvantage — they cannot safely hold much weight, for they are likely to get bent under any great strain. That is one of the reasons why a young baby should not be urged to stand on its feet for any length of time. Active babies like the adventure of the new position; they will want to stand as soon as their bones are strong enough to make it safe, and it is best not to coax them too early. Nor is it good for them to sit all day in a carriage; they need exercise, and if placed on the floor or on a bed, they find many ways of kicking and squirming and creeping which give exercise without putting too much weight on their bones.

Broken Bones. — When bones are broken they will grow together again, provided that the two ends are united and held firmly in position until the live matter in the bone can produce new layers of bone substance at the spot where the break came, thus finally making the bone as strong as ever. When a doctor "sets" a bone he brings the broken ends together and binds them tightly in splints, so that the reunited bone may be straight and perfect. It takes experience to tell when the parts of the bone are rightly adjusted, and a physician ought to be called at once before the parts around the bone begin to swell, thus making it harder to set it. Before he arrives, place the patient in a comfortable position in which it will not be necessary for him to move the broken bone. If the break is in the arm or leg, it may be stretched out on a soft pillow. In case the patient has to be moved, make a stiff splint of a cane or a stout

stick and tie the broken limb around with splint and pillows (coats will do) in such fashion that no strain will come on the broken ends of the bone.

The broken bones of young people often unite in three or four weeks; with older persons it takes longer. Elderly people have an excess of mineral matter in their bones, making them brittle. A fall that would only bruise an active boy is likely to result for his grandfather in broken bones.

Young people sometimes have a form of fracture in which the bone is slightly split instead of being actually broken across. If you bend a dry stick, it will break; but if you bend a green or live stick, it will bend and be likely to split a little without actually breaking. Such a fracture of a bone is called a "green stick fracture" and it is often overlooked for some time.

If the bone is broken in such a way that it has cut through the skin, this is called a **compound fracture**; it is more serious than a simple fracture, because there is danger that disease germs may get in through the wound. While waiting for the doctor it is best to wash any dirt away from such a wound, using clean water, preferably hot water that has been well boiled in order to kill all germs. Then, if available, use some weak carbolic acid or tincture of iodine to wash the wound, covering it with a clean cloth, wet with the iodine or the weak acid.

Misshapen Bones. — Many of the bones of the body become misshapen through improper use; but the stooped shoulders and slouching gait that we often see are more frequently due to badly trained muscles than to any trouble with the bones themselves. The bones most

often deformed are those of the feet. The feet would be really beautiful and shapely if they were not deformed by the constant use of improper shoes. In the olden days most people went barefoot except on Sundays and holidays, and their shoes were made by a cobbler with some reference to the shape of their feet. Now we buy our shoes "ready made," and too often they are selected more because they look fashionable than because they fit the shape of our feet.

Shoes that Deform. — There are only a few dozen different sizes and shapes to be had in shoes, and into them have to be fitted and cramped hundreds of different shaped feet. Not all people are so foolish as to wear shoes too small for them, but unfortunately a shoe that fits one part of the foot may be too large or too small for another part. Hence many ill-fitting shoes are worn, with the result that few grown people have feet that are free from corns or bunions or misshapen toes. Many ladies who are justly proud of their shapely hands would be much abashed if a change in the styles required them to wear sandals that would show the whole foot, so misshapen have improper shoes made their feet.

Often children lay the foundation for much trouble with the feet by trying to wear shoes that are too narrow, on the mistaken theory that if they wear shoes that are large enough their feet will "spread out" and grow larger than they otherwise would. What really happens is that the feet grow to their natural size, just as the hands do. If they are cased in shoes so narrow or so short that they cannot grow naturally, then they will grow as they can; the toes, instead of being shapely like the fingers, will get

to be lumpy balls, with bones bent out of shape, as one toe lies over another (see Figure 62) in order to fit into the narrow toe space of some attractive shoe.

People talk of "breaking in" a new pair of shoes; that usually means persuading their feet to be cramped in a new spot; before long the worst of the discomfort is over, but that is not the end of the matter. A glance at Figures 62 and 65 will show that such cramping of the feet must in the end get them into such condition that walking, which is the best all-around exercise, will become so painful that one does not take exercise enough. If you wish to avoid pain and have comfort in walking when you become a man or woman, be sure to follow the rule of wearing shoes that are long enough, wide enough, and have low heels. Flat foot is becoming more and more common; it is not easily cured but it is readily prevented by a few simple measures. They are:

FIG. 62. — A DEFORMED HUMAN FOOT.
The figure shows a common form of deformity produced by the use of improper shoes.

1. *Wear properly shaped shoes, with broad toes and low heels.*
2. *Toe in or put the toes straight in front when walking.*
3. *Exercise the toes by rising on them with the weight on the little toes as well as on the great toe.*
4. *Do not stand still for long periods at a time.*

Walking does not hurt the feet, but standing still for a long time puts too much strain on the arches. Those who have much standing to do should accustom them-

selves to put their weight first on one foot and then on the other — and above all to *toe in.*

Deformed feet may be produced by shoes with narrow toes or with heels so placed as to throw the weight on

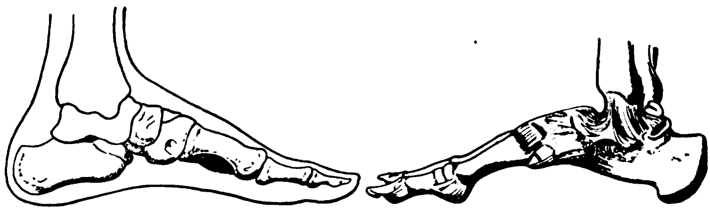


Fig. 63. — The Arch of the Foot.

On the left are shown the bones; and on the right the ligaments that help to support the arch.

the toes. Compare the shape and location of a shoe with a "French" heel with the way your own foot is made. How could one fit the other? You may think the French heel looks stylish, but it is likely to produce pain and discomfort in your future years.

Fig. 64. — A Properly Shaped Shoe.

The Arch of the Foot. — Our feet are really most beautifully adapted by nature to meet the strain that comes upon them. The whole foot does not rest flat upon the ground but touches at the toes and the heel, with an arch between them (Figure 63). The weight of the body comes on the arch, which acts like a spring and makes walking easy and elastic, preventing jars and reducing

fatigue. As long as the arches remain well bent the gait is springy and walking is easy and pleasurable. If a person will wear properly shaped shoes, and will walk with his toes straight forward or even "toeing in" a little, he may expect to keep the arches in good condition. But if he wears shoes that are too tight or are improperly shaped, or if he gets into the habit of "toeing out" when he walks, the arches are likely to give way after a time and he finds himself with the trouble called "flat foot," or "fallen arch." Then all his pleasure in walking is gone, and even when sitting still, he suffers more or less constant pain.

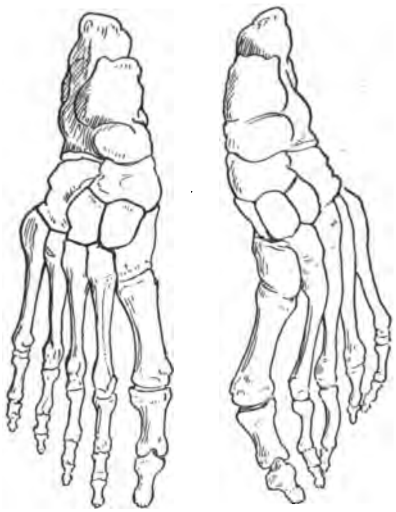


Fig. 65. — The Bones of the Foot. On the left is shown a properly shaped foot, and on the right is shown the distortion produced by improper shoes.

Fig. 66. — The Imprint of the Foot upon a Flat Surface. The normal foot is shown on the left, and the imprint of a flat-footed person on the right.

Recruits for the army, the police force, and other

organizations that require men who are able to drill and to work hard are liable to rejection for flat foot.

A Test for Flat Foot. — Young people do not usually have "flat foot," they merely prepare for cases of it in later life; but it is worth while to test one's feet for

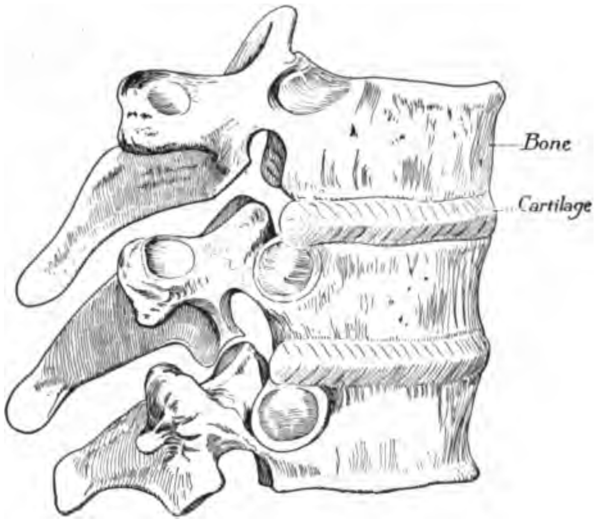


FIG. 67. — VERTEBRÆ.
Showing cartilaginous cushions between the vertebræ.

it if there is occasion to suspect that the arches are falling. A surgeon gives the following simple test which everybody can apply; if you try it and think you detect trouble, you had better ask your doctor to test the arches for you. Test: Put a little water into a basin, and step into it; then while the sole of your foot is moist stand on a piece of blotting paper. Figure 66 shows the pattern that your foot ought to make, and beside

it the pattern that a foot ought not to make. Test both feet.

Cartilage in the Framework. — At various points in the framework of the body we find instead of stiff bones a tough but flexible substance called **cartilage.** The entire framework of the outer ear is of cartilage; and cartilage is used to unite the ribs with the breastbone (it can stand more hitting and wrenching than a bone could). It makes an elastic cushion between the vertebræ of the spinal column; but for its presence there we could not jump about without danger of seriously jarring both the spinal cord and the brain.

How the Joints Work

Joints Necessary for Motion. — The place where two bones are united is called a **joint**; there are **immovable joints** at which the bones are as firmly united as if they made one bone (certain bones of the skull are so joined);

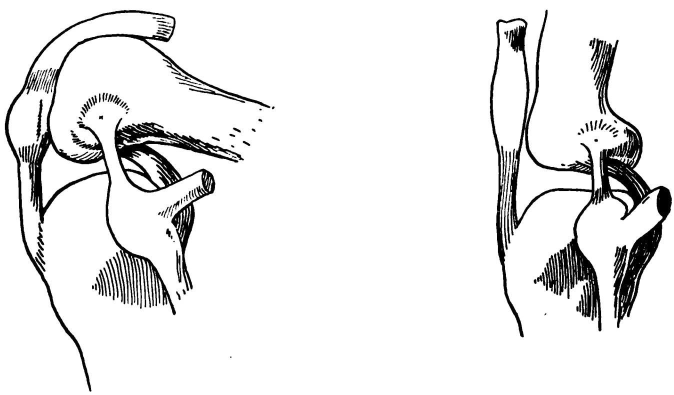


FIG. 68. — BONES OF THE KNEE JOINT WITH THEIR LIGAMENTS SHOWN FROM THE SIDE.

and there are **movable joints**, which allow motion. If it were not for the latter kind, we could no more move than a statue can. The joints are either *hinge joints, ball-and-socket joints*, or *pivot joints*.

Hinge Joints. — The joints that work only in one direction are called **hinge joints**; they open and close as a knife blade does on its hinge; like it they can neither open backwards nor sidewise nor rotate. The joints of the fingers, the wrist, the elbow, the ankle, and the knee are all different forms of the hinge joint. Figure 68 shows the ends of two bones (the thigh bone and the shin bone) which make the knee joint; see how they are shaped to fit each other for movement forwards and back.

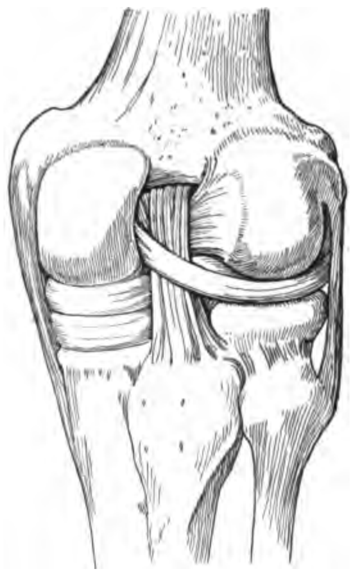


FIG. 69. — KNEE JOINT FROM BEHIND.

The ligaments connecting the bones are shown.

The shape of these two bones would not allow them to move on each other sidewise, but would admit of their moving backwards, which would be very startling. That does not happen because they are held in their rightful position by the **ligaments**, formed of tough, flexible connective tissue, which pass over the joint from bone to bone, and hold the bones together. Figure 69 gives an

indication of the way in which the ligaments are interlaced; they hold the joints so firmly and yet so loosely that while the joints have much freedom of movement they rarely get out of place. The muscles also help to hold the bones in position by the manner in which their tendons pass over the joints.

The hinges of a knife are often so stiff that it is hard to open the blade; yet the hinge joints in our bodies are so adjusted that we are never conscious (except in cases of accident or illness) of difficulty or friction in moving them. In the first place the ends of the bones are so smooth and so rounded that they work together easily; then each one of them has a thin covering of smooth, soft cartilage; and there is also a thin membrane around each joint which produces a liquid, about as thick as the white of a raw egg, that keeps the ends of the two bones moist.

Muscles at Hinge Joints. — A muscle can only shorten itself; if it needs to be lengthened, that must be accomplished by the action of another muscle, which lengthens the first one by shortening itself. Most of our muscles are arranged that way, in pairs; the pair are called **antagonistic muscles** because they do their work in opposite directions; that is, when one shortens, it lengthens the other.

Ball-and-Socket Joints. — In the **ball-and-socket joint,** one bone has a rounded, ball-like head and the other a rounded cavity or socket, into which the head of the first bone fits. The ball can move in any direction in the socket, and that makes this kind of joint a very freely moving one. There are only two pairs of large ball-and-

socket joints, one at the shoulders and the other at the hips. Figure 70 shows the bones that form the shoulder joint as they look with the skin, muscles, and ligaments removed. There is a very shallow cup in the shoulder blade (*scapula*), and the upper end of the arm bone (*humerus*) is rounded and fits into it. The figure shows two bony projections over the joint which limit the extent to which the ball can move in that direction; but even though thus limited the arm at the shoulder has very free motion in all directions.

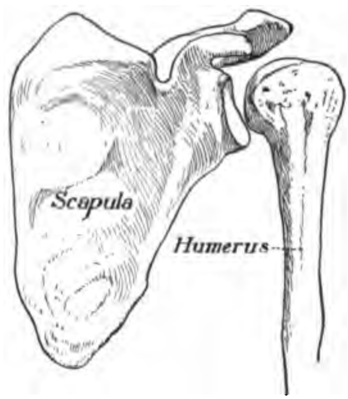


FIG. 70. — THE BONES OF THE SHOULDER JOINT.

The ball-and-socket joints, like the hinge joints, have a smooth cartilage and a lubricating fluid. The bones are also held in place by ligaments. The shoulder has one large ligament, a loose, leathery sac, shown in Figure 71, which is fastened to the shoulder blade; it passes over the joint in such a way as to cover it on all sides. Its other end is attached to the arm bone and helps hold the rounded bone of the arm in the socket. There are also strong muscles that completely cover the joint. The tendons from the great shoulder muscles pass over the joint and are attached to the bone of the arm, thus making a strong connection that helps hold the ball in the socket even under great strain.

The hip joints have a deeper socket and their motion

is not quite so free as is that at the shoulders. Where the fingers and the thumb join the hand there are joints which are sometimes referred to as modified ball-and-socket joints. They are, however, very differently shaped from those at the shoulder and hips.

Evidently ball-and-socket joints require a larger number of muscles than the hinge joints, since they may be asked to move in nearly every direction. Figure 55 gives some impression of the number found around the shoulder joint.

FIG. 71. — THE SHOULDER JOINT WITH THE LIGAMENTS THAT HOLD THE BONES TOGETHER.

Pivot Joints. — There is a third type of joint in the body, called a **pivot joint**, because one of the bones remains stationary and the other one moves around it; the joint that enables us to rotate the head is one of that kind, and the one at the wrist that enables us to turn the hand over is another.

How Joints Are Injured. — It is seldom that bones are broken at a joint because the joint will pull apart under great strain. A wrench sometimes pulls the ball of the arm bone out of the socket, producing a **dislocation**; it may not injure the bones at all, but it is likely to tear protective coverings, ligaments, or tendons that hold the bones together. In that case, one has a **sprain**

in addition to the dislocation. A physician can easily put the bones back into position, so that from a simple dislocation there would be temporary discomfort only; but if the ligaments and tendons are torn, the injury cannot be repaired quickly because they are not plentifully supplied with blood vessels. Often a violent strain only tears the ligaments, producing a sprain without any dislocation; but such a sprain may be more serious and may be slower to heal than are simple dislocations or broken bones.

Formerly when people had a severe sprain in the ankle they were kept in bed and were not allowed to use the sprained ligaments for weeks. This resulted in making the joint stiff and painful to use. Now physicians generally bandage the sprained joint so as to help keep the swelling down and then encourage the patient to exercise it moderately; the result is better circulation, which will produce a more rapid repair of the injured parts.

A severe sprain requires the attention of a physician; but before he comes, the joint should be raised, for this helps keep down the inevitable swelling, by preventing the blood from collecting. Applications of either very hot or very cold water should be made; and sometimes both are used, hot water being followed by cold to produce a stimulus. If the injury is too slight to require the care of a physician, it is still best to give it the treatment above suggested. Massage (i.e. rubbing) is also very effective, as it increases the blood supply and keeps the joint, which is not having its normal amount of exercise, from getting stiff.

QUESTIONS

1. Compare a baby's bones with those of an adult. Why is there such a difference?

2. Is there any blood in bones? If so, how does it enter them?

3. Can you give any reason why the femur is stronger than the humerus?

4. Why is the frame of a bicycle made of hollow tubes instead of solid bars?

5. What happens when the animal matter is taken out of a bone? When the mineral matter is taken out?

6. When a bone is broken, how does nature repair the damage? What is necessary in order that this may occur? What happens if a broken bone is allowed to "set" in a wrong position?

7. If you were with a friend in the woods and he should break his arm, what would you do? What could you use as a splint? As bandage and padding? As a sling?

8. If both you and your father should break a leg at the same time, which would probably get well first? Why?

9. Why does not an old man dare to jump from a fence that you are not afraid to jump from?

10. How may the bones become misshapen? When is this most apt to occur? How may it be avoided?

11. What may happen if you wear shoes that are too tight? Shoes that are too short?

12. Name some classes of people who are likely to have "flat foot."

13. If you had a hinge joint at the neck, what motions could you make with your head? What motions could you not make?

14. If you had no joint at your knee, could you walk? Try it and see. Could you walk if you had no hip joint?

15. Can the bones at a joint move of their own accord? What must move them?

16. Which kind of joint has more muscles, a hinge joint or a ball-and-socket joint? Why?

17. Which would recover more quickly from a sprain, a person who rested the joint or one who used it as soon as possible?

CHAPTER IX

EXERCISE: STRENGTH AND GRACE OF BODY

Taking Exercise. — When people "take exercise," what parts of the body get the exercise? Almost all parts of the body share in it to some extent; the parts directly concerned are the bones, the ligaments and tendons at the joints, and the muscles, including not only those used in walking, or whatever the exercise may be, but also the heart muscle and the breathing muscles. The nervous system also gets exercise, for it directs the action of all those muscles.

Both nerves and muscles benefit by having plenty of work to do. The muscles grow stronger and the nerves become able to do their work with more certainty and speed. The pitching of a baseball and the playing of a violin require a complicated series of muscular movements to take place simultaneously, each one so nicely gauged that it shall balance another. So we practice and practice; which really means that we repeat the motions so many times that the nervous system learns just how to direct the making of them perfectly. The muscles *show* their improvement by growing larger as they are used. There are some occupations in which certain muscles are worked very hard, while the rest of them get little exercise. Which muscles are developed by the hod carrier, the stone cutter, the bicycle rider, the laundress,

the gardener, the hammer thrower, the oarsman? Which muscles do each of these occupations leave without exercise enough?

Corrective Exercise. — Many a man tends to get bent over with his work or acquire some muscular habits that make him ungraceful; he cannot change his work, perhaps, but he can offset its bad effects. Fortunately a few minutes of well-directed exercise taken regularly every day will counteract the effects of hours of cramping work. Then too we all need some general exercise that shall bring into play those muscles that we are not using regularly, for the really strong man is the one who has developed all of his muscles. This is particularly necessary in these days when automobiles, trolley cars, and elevators are weakening our legs, and easy-chairs and hammocks are weakening our backs. It is time for us to remember what befell the hermit crab (Figure 72). Originally that crab was fully protected by a hard shell, but when it acquired the habit of thrusting its abdomen into the shell of a snail for protection, it ceased to use its

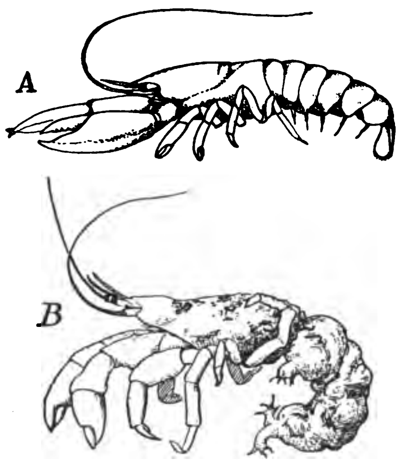


FIG. 72. — THE HERMIT CRAB.

A, the type of animal from which the hermit crab originally came; *B*, the hermit crab, showing the soft, flabby abdomen produced because the animal thrusts its abdomen into a snail shell for protection.

own shell and so gradually lost it, thereby becoming the flabby, misshapen, absurd thing it now is.

Common Sense in Exercise. — The man who gives his body too much severe exercise is a little more foolish than the one who takes none at all. The first is likely to die in middle life, as many athletes do, from the undue strain that he puts on the heart; the second may live to old age without taking exercise, though his body and his mind will never be as active, never accomplish as much as they might have done. If it were not that the happy games of his childhood had given all his muscles a chance to grow, many a man would not be able to perform his work; if he could be an active boy again for even fifteen minutes a day he would feel the benefit. We should all be able to do every day a much larger amount of work than we think possible if we would only keep the body machine in proper condition.

Out-of-door games are much better than the same amount of work in a gymnasium. From listless exercise of any sort we get only an indifferent amount of good. Walking five miles a day would be sufficient exercise for a business man, but poor allowance for a growing boy, whose instinct tells him that running is better than walking. There is much work in a house or about the grounds that may be done with the briskness and spring that make exercise of the greatest benefit.

Many a college student, ambitious of distinction in his work, has tried to get more time for study by cutting down his time for exercise; he usually finds that the time he gains in that way is really lost, for an hour's study after exercise, when one's mind is keenly alert, is worth

more than two hours of listless study, with wandering attention.

Fatigue from Exercise. — A man who is taking violent exercise may feel very much fatigued long before his muscles have done all the work that they are able to do without discomfort. It is not because his joints are weary of working or because the nervous system is tired of giving commands; the trouble usually is due to the so-called **fatigue poisons** that are made by the muscles when they work. At first the poison is carried off as fast as it is made, but little by little it begins to accumulate in the system, and the man begins to be distressed by it. The heart is not able to pump the blood around fast enough to carry off the poison. When that point is reached, to go on exercising only increases the trouble; one should stop and give the system a chance to get righted.

That is why the whole system is tired when a single muscle is completely fatigued. If a boy takes a long, hard walk, he cannot come home and study to advantage. His elders used to expect him to do it, but experiments in many laboratories have shown that the boy is right in saying that it is impossible. In laboratories men have apparatus by which they can measure accurately the amount of work that a muscle can do; they find that when the legs are tired, the muscles of the fingers cannot do much work; that after an examination the muscles of the legs cannot do as much work as they could when the examination began. Stated another way, this means that if you have to study, you must not play too long.

In cases of excessive fatigue, a very hot bath, not more than five minutes long, will help; it should be followed

by quiet sleep, for during sleep the body can recuperate faster than when it has many other things to attend to as it does when we are awake, no matter how quiet we think we are keeping.

Well-directed Exercise. — In one way, taking exercise is like taking medicine; the right amount of medicine is much better than a large dose. It is never well to use the muscles as hard as one can; for light, regular exercise actually builds the body up better than the lifting of heavy weights. The muscles need to work, and then they need rest.

One good rule to remember is: Don't spare your weak muscles. They are the ones that need exercise. If you are right-handed, remember to do with your left hand certain things that do not require accurate muscle control, like opening doors, lifting bundles, digging in the garden, etc.; that will mean adding a number of new and willing servants.

Muscular Stimulants. — The only real stimulants for healthy muscles are exercise, work, and active play. There was a time when the word "stimulant" would have suggested immediately the use of some form of alcoholic drink; people knew that they *felt* more powerful after taking a little alcohol, so they thought it helped to make the muscles work. Then test after test was made, in the laboratories and in active work. Alpine climbers were watched to see how much work they could do with alcohol and how much without; many experiments were made with armies, in cold countries and in hot countries; they tested athletes; they tested ordinary men, day after day. The testimony was all against the use of alcohol,

for it was found that alcohol deceived the men who used it; although they felt that they were doing more with it, they were usually doing from 10 per cent to 30 per cent less.

The records made by the tobacco users have also been watched; it is found that tobacco never favors the growth of the muscles. In some universities comparative records of smokers and non-smokers are kept; these show that non-smokers gain about one-quarter more in height and girth of chest during their college course, than the smokers gain; also that, taking all the body measurements into account, smokers at eighteen are barely the physical equals of seventeen-year-old non-smokers.

Strength and Grace of Body

Strength May not Give Grace. — A blacksmith has strong arms, a ditch digger strong hands, a mail carrier strong legs; with all this strength they may be clumsy unless some exercise is given to the muscles not used in their daily work. The really graceful person is one who has *all* his muscles properly developed and whose body is well poised, whether at work or at rest. Rest is an active process; it is not gained by simply letting the body relax. The boy who slouches down on to a bench after taking his turn at the bat is really not getting the rest he would get if he were sitting properly and is not developing a graceful body.

Good Poise Is Admired. — Good poise is as much needed in all kinds of athletic work as it is in the schoolroom, or at a reception. Do you wish to be attractive in

appearance? You cannot, perhaps, change the features of your face, but you can develop a graceful body. A graceful carriage, good poise, are always more admired than beautiful features. The person who is stoop-shouldered, who lounges in his chair or at his desk, who shuffles his feet or slouches when he walks, is not admired by any one. Contrast him with the West Point cadets; many a boy goes to West Point who is not erect and graceful, but day after day he is put through exercises that develop his muscles and teach them to work together smoothly. The result is the "well set-up," alert man whom everybody admires. It is not only in the army that well-formed, erect, vigorous men are desired. For what position or occupation would not such a man have the advantage over his lounging competitors?

FIG. 73. — THE SPINAL COLUMN.

Showing the graceful curves.

Common Causes of Bad Poise. — When a person stands, sits, or walks badly, the cause may be simply heedlessness, or there may be some trouble with the bones or the muscles. By carelessness in childhood, when the bones are growing and hardening, they sometimes become misshapen. The bones of the legs may bow out, or the spine may get a forward curve, or the bones of the fingers may become crooked. After twenty years of age there is little that can be done to correct any misshapen bones;

they must remain as they are then, possibly growing worse as the years go on. Fortunately misshapen bones are not frequently found. Generally the defect is not in the bones but in the failure of the muscles to use them properly. The remedy is the training of the muscles, and this may be attempted even in middle life. To be sure, progress then is slow, and, when you are grown up, it will take months to do what you can now do simply with a little attention to the position assumed at work and at play. The child's body is pliable and tends to mold itself to the shape which it habitually takes.

It seems to us a serious matter when a man has to have a broken leg set in the woods, far away from a physician, and then finds that because it was set wrong it has grown permanently crooked. Yet in a small way we are doing a similar thing to ourselves when we continually set some group of muscles wrong; we are helping to make for them a habit of action or inaction that cannot later be broken without much effort and difficulty.

Unused muscles become small and weak. If we get the habit of relaxing our muscles and sitting back into a comfortable easy-chair, we are weakening the muscles that hold our backs upright; they will lose their vigor, and what ought to be a natural position for us will become difficult and uncomfortable. *Leaning* is another foolish habit; leaning against a chair or a counter or whatever support may be at hand does not really rest us. One tires quickly if one has to stand still, for standing keeps the same muscles contracted for a long time, while when one is moving about different muscles are at work. The way to rest, if one has to stand for any length of time,

is to put the weight first on one foot and then on the other. The muscles are well satisfied with that kind of rest, especially if the weight is kept forward on the arch of the foot and the feet are either placed straight frontwards, or with the toes turning slightly inwards.

Flat chests are most unattractive, particularly in women; yet all girls, when they are young, may easily acquire a well-curved chest. It is most readily gained by using the muscles on the back of the shoulders. An exercise which calls these muscles into play is to first clasp the hands above the head, and then behind it. The best exercises for developing the chest are those that give the motions one makes in pulling candy. See how you can introduce some of the other motions into your games.

Deformities of the Spinal Column. — Figure 73 shows the beautiful curves that make the spinal column so strong and yet so flexible. Additional curves in it are very undesirable. By careless habits many people acquire a *backward curvature* of the spine that is most unattractive, and like other deformities the outer defect is not nearly so serious as the inner misadjustments. Boys and girls have it in their power to determine the shape and appearance of their bodies for the rest of their lives.

If the spinal *curve in the neck* is allowed to become too great, a person walks with head thrust forward and with stooping shoulders; if the curve in the lower part of the back is accentuated, the abdomen protrudes, giving a very unpleasing appearance. Both these defects are easily avoided by correct habits in standing and sitting. The remedy is not to "hold in" the abdomen, or to do something queer and uncomfortable to the shoulders. Strain-

ing does not put the body back into poise; that can only be done by correcting the root of the difficulty, that is, by straightening out the unnecessary curve that has been put into the spine. One direction often given is, *stand*

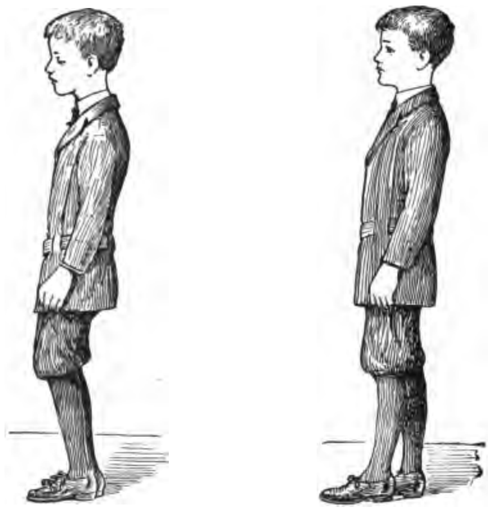


FIG. 74. — A BAD AND A GOOD POSTURE.

Due to correctly and incorrectly curved spinal columns. Which do you prefer? You can have either.

tall; another is, *always keep your neck pressed back against your collar.*

Poise in Standing and Sitting. — Watch yourself when you are standing to see whether you have the bad but common habit of standing with the weight on the heels. The weight should be on the arch of the foot. If you have difficulty in placing the weight there, try to carry it still further forward to the front of the foot; you will then find that you can more readily transfer it to the arch.

In the army, men are trained to sit erect; when you have a chance to see an army officer at work at his desk, you will not see him slouched over, or leaning back to find a "comfortable" position. He can *work better* when sitting up and paying attention to his work; and he has discovered that he can *rest better* by letting the muscles hold the body up than when some of them are cramped and others are stretched by dropping into a half-reclining position. A good rule as to position is this: sit erect when you sit; lie down when you need rest.

How to Walk. — Walking is excellent exercise when done properly. The most common fault in walking is using the heels too much and the toes too little. Easy and graceful walking requires that the weight of the body should be thrown upon the ball of the foot as it touches the ground. When the heel comes down first, the effect is less graceful and more tiring, and that method is partly responsible for broken arches and flat feet. At first one may find it tiresome and difficult to change one's habit of walking; the muscles have been adjusted to the heel-first gait. A little persistence, however, will result in the formation of habits in walking which will prove a lifelong blessing.

How to Exercise. — In most games and sports the arms and the legs are exercised. It is important not to forget the *muscles of the trunk*, for when their tone is good they hold the important organs of the abdomen in place. Any exercise given to them serves a double purpose, for it also promotes the circulation of the blood and the lymph, thus providing for a more rapid removal of the waste products from the body.

Ask the oldest and the wisest person you know whether people get on in the world by doing easy things or by doing hard things. All of us are pleased when we have learned how to do a hard thing well; but we do not always remember this when the hard task comes. The way to take hard things, in games or in study or in exercise, is with a dash, going out toward them not grudgingly, but determined to get out of them all the good there is in them.

The Value of Games. — Active games, played with a will, exercise the heart and the lungs and at the same time use all the muscles; they also train the senses and the power to think quickly and to decide rightly. They are good training for life. Young people who excel in games and sports usually enjoy them; those who do not excel need to learn the very things that those games would teach. In the olden days, when nations took charge of the activities of their young people to insure having the right kind of citizens growing up, the young were given as careful training in various athletic sports as in any branch of learning. No excuses were accepted; if a boy "did not like" some exercise, he was regarded as defective and trained in it with particular care.

Exercises for Suppleness and Grace. — To secure a graceful carriage the muscles must not be overdeveloped, and their development must be well balanced. They must be strong and under that perfect control which comes from constant use. The kind of exercises best adapted to bring this about are such as the following:

Balancing exercises, like walking on the rails of a railroad track or on any narrow board, with the hands hanging loosely at the sides.

Dancing of all kinds, but especially those types of folk dances which involve the use of the arms in harmony with the legs.

Jumping forward or backward or to the side, with the knees bent, especial care being taken to land lightly rather than to jump far.

Shifting the weight of the body rapidly; (1) Step forward on the right foot, raising the arms (with muscles relaxed) at the sides, and hopping on the right foot; then step forward on the left foot and hop in the same way. (2) Step lightly a long step to the right, raising the right arm with the elbow and wrist slightly bent over the head, and with the left arm curved in front of the body; then change the position of the hands and step on to the left foot and hop. This exercise may be continued alternately first on one foot and then on the other.

QUESTIONS

1. Which is better as exercise, work or play? Give reasons for your answer.
2. What effect does exercise have on the muscles? On the nerves? On the shape of the body?
3. Name some kinds of work that are apt to affect one's health and bodily proportions.
4. Tell some kinds of exercise that are good for the development of the arms, the back, the lungs; some that are good for the development of all parts of the body.
5. What happens if we do not exercise enough? What happens if we do not exercise one set of muscles at all? Is it possible to exercise too much?
6. What is meant by "fatigue poisons"? How does nature take care of these?
7. Can you study well after taking moderate exercise? After very

vigorous exercise? Can you work well after studying hard? Can you study well after working hard?

8. Which will make the better business man, a boy trained in games requiring accuracy and coöperation with others or one whose play is spasmodic and unformed? Which will make the better student? The better soldier?

9. Which can probably lift the heavier weight, a ditch digger or a postman? Which can walk farther? Why?

10. If some of your muscles are weak, do they need rest or exercise?

11. Why do trainers of athletes forbid them to use alcohol or tobacco? Why do the big railroad companies refuse to hire young men who smoke cigarettes?

12. How does excessive exercise of one set of muscles affect the body? How does moderate exercise of all the muscles affect the body?

13. What kinds of exercise prevent round shoulders? What kinds prevent weak backs? What kinds improve the action of the lungs and heart?

14. What happens to a boy or girl who sits in a bad position? What should such a boy or girl do? Which is more restful, sitting properly or sitting badly? Does this seem always to be true? Give reasons for your answer.

15. If you carry your books always on one arm, what is apt to happen to your body? If one shoulder is lower than the other, what exercise should you take to counteract this defect? If you are in the habit of holding your head thrust forward, how can you overcome this fault?

16. Some time try the experiment of standing in front of a mirror in your usual position. Without moving your feet, see how much *taller* you can make yourself. Which position do you like best? Try the same experiment sitting in a chair, also sitting on the floor. Do you get a correct position in each case?

17. If you get in the habit of relaxing the muscles of the back, what effect has this on the lungs? On the stomach? What effect on the general health?

CHAPTER X

REMOVAL OF BODY WASTES

Preventable Poisoning. — Few people appreciate the extent to which poisonous wastes are produced in their bodies as the necessary result of life processes, or the extent to which illnesses, both slight and serious, are due to the accumulation of poisons in the body. In fact if we include together, under one head, the poisons produced in our bodies by disease germs and those manufactured by the body itself as it works, there would be no exaggeration in saying that the great majority of all deaths are due to poisoning; and in many cases to preventable poisoning.

Production of Wastes. — A locomotive always produces waste products when it is drawing a train of cars. Some of these wastes, the smoke and the hot gases, pass out of the smokestack; others, chiefly ashes, fall into the firebox and from there on to the track. If the fireman did not keep the grate free so that the ashes could pass through, or if the smokestack were stopped so that the smoke and the gases could not escape, the fire would go out and the train would come to a stop.

The body is in much the same position; every part of it produces some waste as it works. Food is the chief source of these wastes, and they are produced when the food is oxidized (burned) in the body. The living tissues

are being built up and renewed by our foods, and the foods are also used to give us heat and energy. When food is used for any of these purposes, it is broken up, and from it come various substances that must be gotten rid of, just as the ashes and smoke must be removed from the locomotive. From our carbohydrates and fatty foods the wastes are carbon dioxid and water; from our proteids the wastes are carbon dioxid and water and a substance called **urea**, together with small quantities of various poisons. When the muscles work, they also produce another kind of poison that has been called *fatigue poison.* All these substances, together with other wastes, are removed by the several means that nature has provided.

How the Body Wastes Are Removed

From Intestines and Liver. — A portion of every meal we eat consists of food that is either indigestible or undigested. There are also the wastes that have been taken from the blood by the liver, and sent with the bile into the intestine. All the waste matter finds its way into the large intestine where there are always bacteria ready to cause it to putrefy; it then becomes a source of danger if it is allowed to collect. Safety requires that this waste should be expelled once or twice a day at a regular hour.

From the Lungs. — Carbon dioxid and water are constantly passing off from the lungs.

From the Skin. — Everybody knows that waste matter is given off by the skin, for the odor of the **perspiration,** especially when one is working hard, shows that it con-

tains waste products. What is perspiration? It looks like water as one sees it standing in thick drops on the forehead, when the day is very hot. Dissolved in that water are waste products which the body is able to get rid of through the skin.

Perspiration is being thrown off all the time, all over the body, even in the winter and even when we are asleep. Usually we do not notice it because the perspiration (called *insensible perspiration*) evaporates from the skin as fast as it is formed. This can be proved by holding the hand tightly closed for a few minutes; you will notice that the palm becomes moist with the perspiration that could not evaporate from the closed hand. When it forms faster than it can evaporate, then it collects on the skin and we say that we are **sweating** because we can see and can feel the sweat drops.

How the Kidneys Remove Wastes

What the Kidneys Do. — The most important of all the waste products from the proteid portion of our food is the substance called urea. The body cannot work unless the urea formed is constantly removed; to accomplish this, it is necessary that both the liver and the kidneys work together. First the liver turns the waste products from our proteid food into urea; this is then taken by the blood to the kidneys, whose chief business is to remove it from the body. Through the kidneys the blood also gets rid of much of the water that is no longer of use; and they are also able to help other organs of the body to dispose of special poisons. Drinking plenty of water every day helps the work of the kidneys. Water

never clogs the system; it is readily disposed of, and it makes easier the work of every organ that shares in the work of excretion.

Importance of Their Work. — The kidneys are small organs. There are two of them, usually a little different in shape. One would never imagine from looking at them that they had such important work to do. Sometimes other organs that we consider absolutely necessary to life, like the stomach, have been removed and the body has gone on working without them. But the kidneys, like the heart, have no substitutes standing by ready to do their work if they should fail. The skin can help them out a little, the intestines can give them a still smaller amount of help; but if their work remains undone, even for a few hours, poisons accumulate in the body and death must result. Slight disturbances of the work of the kidneys have serious effects; and most of these are either avoided or at least lessened by the simple expedient of drinking sufficient water.

How the Kidneys Work. — The kidneys lie behind the lower part of the stomach, in the back of the abdomen, one on each side of the spinal column. In a grown person they are about four inches long and an inch and a half wide. The colored picture on page 110 shows that their shape is much like that of the kidney bean which was named from them. The blood, from which it is their duty to extract the urea and some other wastes, is brought to them by a large artery, and carried away by a large vein. The capillaries of the kidneys are very numerous and they are so arranged that the thousands of small tubes, called **kidney tubes**, have every opportunity to take out

from the blood the water and the urea that should be removed. This is collected into a much larger tube, called the **ureter**, which carries it to the bladder from which the waste is voided.

The kidneys are at work continuously; they usually have more liquid to excrete in the winter months than in summer when one perspires freely, but exercise, or anything else that stimulates the circulation of the blood, will also increase their action.

When the bladder is nearly filled, there is a natural demand for emptying it; and it is really much more important that this demand should be met than that we should meet the appetite for food. The body can get along without food for several days and suffer no harm, but if the poisons that are gathered in the bladder are not allowed to pass off, they will rapidly injure the bladder and soon poison the whole system.

Kidney Diseases. — Many remedies for kidney diseases are advertised, and lurid accounts of the symptoms of kidney trouble are often printed; but sensible people pay no attention to such efforts to get money from the ignorant. When the kidneys are really diseased, the attention of a good physician is required, not some dose of patent medicine.

The two most serious diseases which result in abnormal kidney excretions are called diabetes and Bright's disease. In **diabetes** sugar is excreted by the kidneys; and in the most common form of the disease this is due to the failure of the tissues of the body to make use of the normal amount of sugar as a fuel food. Muscular weakness is one of the results, because the muscles are not getting

enough fuel food. The cause of this form of the disease is not fully known.

In **Bright's disease** the kidneys excrete albumen, which under normal conditions would be used for the repair of the body and as fuel. It is one of the ways in which a general breakdown of the body mechanism shows itself. These diseases are becoming more and more prevalent, hence we all ought to take pains to use the best preventives against them. The most important are simply drinking plenty of water and not overeating; the others are the maintenance of the whole system in healthy, vigorous condition.

QUESTIONS

1. Which will cause death more quickly, going without food or allowing the poisons of the body to accumulate?
2. Name the chief poisons that are produced in the body. How has nature provided for ridding the body of each?
3. Where are the kidneys? What do they look like? How important to the health of the body is the work of the kidneys?
4. Describe how the kidneys perform their work.
5. Do you think an insurance company would be likely to insure a man who had any disease of the kidneys?
6. How do the liver and kidneys work together?
7. What health rules should one be sure to obey if he would keep the organs for the removal of wastes in a healthy condition?
8. Would you expect a man who eats heavily of rich food, generally drinks beer with his meals, and is carried to and from his place of business in a limousine, to be strong and well? Why? In what ways would you consider his chauffeur as more fortunate than he?

CHAPTER XI

STRUCTURE AND FUNCTIONS OF THE SKIN

Structure of the Skin. — The skin covers the entire body like a garment, fitting loosely in some places, as on the back of the hands, and fitting tightly in others, as on the palm of the hands. A grown person has about sixteen square feet of skin.

What we are accustomed to call the skin is only its outer layer. Looked at through a microscope, a cross section of skin shows two layers (Figure 75). The outer layer is called the **epidermis**. The inner layer is called the **dermis**; this is the more interesting one, for it is all alive and is full of nerves and blood vessels. The epidermis, except for a thin layer on the inner side, is practically lifeless and contains no nerves and no blood vessels. It is easy to test the thickness of the epidermis by pricking the flesh with a pin. At first you feel no pain because the pin is going through the lifeless epidermis; the pain begins when the point reaches the dermis.

Outer and Inner Skin. — Lifeless things do not grow, and the lifeless outer surface of the epidermis shows no growth; yet the outer skin is growing all the time on its inner surface which is alive and in contact with the dermis. The outer and inner skin are so firmly attached that they are not easily separated, and this is a great protection to the tender inner skin. We realize how tender is this

inner skin when a **blister** breaks and the outer skin peels off. Small blisters should be carefully opened by pricking the skin at one side of the blister. That gives relief by letting out the watery matter that has formed between the two skins, and it leaves the outer skin over the blister to protect the dermis.

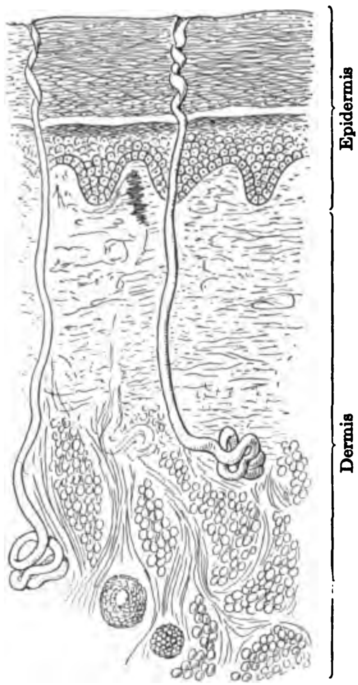


FIG. 75. — SECTION OF THE HUMAN SKIN.

Figure 75 shows that the dermis is much thicker than the epidermis, and consists of a mass of fibers, running in every direction. On the side next to the epidermis the fibers are packed close together, while below they are less dense. Between the fibers lie tiny fat cells, and throughout are many blood vessels and many nerves; hence the dermis always bleeds when cut and is very sensitive.

Hair. — The epidermis has several outgrowths which do not in the least resemble it; one of these is the hair. Each hair extends into a little pocket of its own, called the **hair follicle.** At the bottom of each pocket is a very small mound, or **papilla**, which may be called the root of the hair. The hair is constantly growing at its root, and as it grows it is pushed out of the pocket. When a hair is pulled out,

there is usually no injury to the papilla, which proceeds to grow a new hair. But if the whole follicle, including the papilla, is destroyed, no new hair will grow.

Each hair is supplied with oil from one or more tiny *glands* that open into the follicle from the sides, as shown in Figure 76. The oily substance they produce distributes itself over the surface of the hair and keeps it soft and flexible. Being lifeless, the hair is not connected with the nerves, and there is no sensation in it. When an inch of a girl's braid is cut off, she only knows that it is gone when she hears the scissors cut or sees the bit of hair. There is hair on all parts of the body excepting the palms of the hands and the soles of the feet. In places where it just barely reaches the surface we often do not notice it.

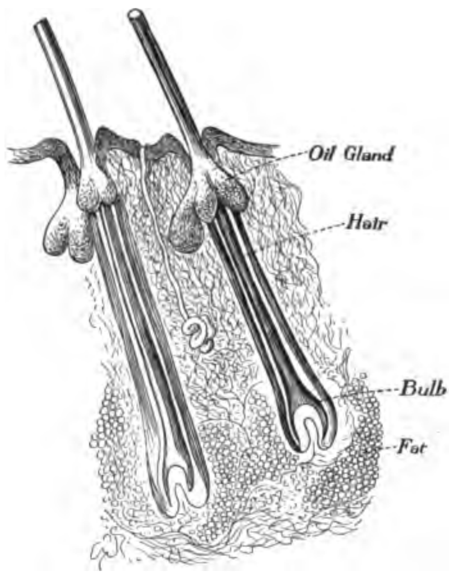


FIG. 76. — SECTION OF THE HUMAN SKIN, SHOWING TWO HAIRS.

The Nails. — Other outgrowths of the epidermis are the finger nails and the toe-nails; they are of a horny substance, and like the hair are lifeless and have no feeling. Pressing too hard on a finger nail does not cause pain in the

nail, but in the delicate skin that lies under it. Pulling the nail hurts, while cutting it does not, because the pull is felt by the nerves in the finger where the nail is attached. The nail is continually growing outward from the root. When injured seriously, a nail will come off, but a new one grows again unless the root has been badly injured. The half moon near the root of the nails is of the same substance as the rest of the nail; the difference in appearance is due to the fact that at this point the nail is new and thin and underneath it there are fewer blood vessels.

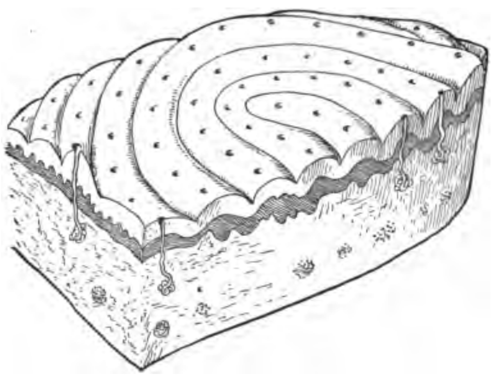


Fig. 77. — A Bit of the Human Skin.
Showing the sweat glands and pores and the different layers of the skin.

Sweat Glands and Pores. — Sweat, as a means of carrying off some of the body waste, has already been discussed. We can readily see the sweat drops, but the **sweat glands** that produce them are too small for us to see. There are some two and a half millions of them in the skin. They start in the dermis as coiled tubes; the tubes pass up through the dermis and the epidermis, and open at the surface in what are called **pores**. There are as many pores as there are sweat glands, and through them the sweat comes to the outer part of the skin (Figure 77). The skin of the whole

body is covered with these tiny pores; they are most numerous upon the forehead, the palms of the hands, and the soles of the feet.

The skin of the fingers is covered with irregular furrows; and the pattern of those furrows is different with every person. The thumb print shown in Figure 78 is that of the author of this book, and no one else in the world has one like it. Since no two persons have the same markings on their fingers, these finger prints are a far surer method of recognizing a person than his photograph; hence their use by the police to detect and recognize criminals. The pores lie on the ridges between these furrows, as seen in Figure 77; even a small magnifying glass will show them.

FIG. 78.—A THUMB PRINT.

Functions of the Skin

The complicated structure of the skin and the number of its accessory parts show that it is designed to serve many different purposes. Its use as an organ of excretion has already been described; it has three other important functions which are so nicely adjusted to one another that they all go on at the same time without the least conflict or interference. The skin *gives protection* to the body without losing any of the sensitiveness required in an *organ of sense;* and it uses the same sweat glands for eliminating waste and for the much more important purpose of *regulating body temperature.*

1. **As a Protection.** — The flat, scale-like cells of the

outer skin, packed close together, many layers deep, give great protection to the flesh beneath. The chemist can plunge his hand into a poisonous liquid without danger, because the poisons cannot get through the cells of the epidermis. In the same way this outer guard of our bodies prevents dangerous disease germs from getting into them. Some of these various germs are always on our skin and our clothing, and if they can get into the body, they will grow there and produce trouble.

2. **As a Sense Organ.** — When sense organs are mentioned one thinks of the eyes, the ears, the nose, and the tongue; but the sense of touch, which is located in the skin, makes it one of the most important of the sense organs. In the skin too is our sense of temperature, for it is chiefly through the skin that we feel heat and cold. Some of the tiny microscopic organs in the skin are, as we have seen, affected by heat and cold, and there are others that are affected by pressure; each responds quickly to its own stimulus, and, through the messages they send, the brain is constantly being given information about what is touching the skin.

3. **As a Regulator of Body Temperature.** — All parts of the body have to be kept at a comparatively even temperature, or else we become ill. Sometimes our bodies make too much heat and at other times too little. If we exercise vigorously, the muscles produce so much heat that the body would be too warm if it could not get rid of its excess heat. The maintaining of the proper temperature rests upon the sweat glands of the skin and its blood vessels.

It may be easier to understand how they accomplish

their task if we consider the means by which the heat of a room is regulated. We know that the amount of *heat admitted*, to a schoolroom for instance, must be rightly proportioned to the amount of *cold air admitted;* in the winter it is necessary to be alternately opening the hot-air registers and closing the windows or vice versa. The body uses similar measures, only under ordinary conditions the body's temperature depends more upon the opening and closing of its windows (i.e. the increasing or checking of skin circulation) than upon checking or increasing the amount of heat produced.

Heat Production. — The heat manufactured in the body cannot be governed wholly by the question of the amount needed to maintain an even body temperature. The muscles must keep working, and when they work, heat is produced even though the day is warm and the body happens for that reason not to need the heat. In this respect the body might be compared to a kitchen range whose heat must be kept up even on a hot day in order to do the cooking. To make the kitchen comfortable to work in, the windows must be opened to help cool the air. The heat made in the body is determined by the body's activities; when they result in more heat than the body needs, the regulating apparatus has to work hard in order to get rid of the extra heat.

Heat Regulation. — The regulating process is simply this: The temperature of the skin is about 95°, which is always lower than that of the interior of the body and is usually higher than that of the air with which the skin comes in contact. So the warm blood that fills the many small blood vessels of the skin is constantly being cooled

by the air; the faster the blood flows through the skin, the more it is cooled. When there is too much heat, the blood vessels of the skin expand, more blood flows into them, more heat is lost, and the body is cooled. This does not mean that we *feel cooler.* We may actually feel warmer because of the amount of warm blood flowing through the skin; but, however we may feel, the fact is that the body is relieved of its excess heat.

When the body is making too little heat, the blood vessels in the skin contract until their tubes are very small and hence will let only a little blood through the skin. By checking the heat outlet from the skin the heat is kept within the body. At the same time the skin becomes pale and the person is likely to feel cold; this feeling of cold is not due to a drop in the temperature of the body, which is being carefully kept at 98.6°, but to the tiny organs in the skin that feel heat and cold. When there is less warm blood flowing around them, they send a cold report to the brain. On a hot day, or whenever much blood is sent to the skin, the same little organs report heat, though the actual temperature of the body is no higher than it was on the day when they reported cold. The temperature reports that the brain gets from the skin are of skin temperatures only. The brain receives few other temperature reports except from the lining of the mouth and of the digestive tract.

The lungs also help to dispose of excess heat. The air drawn into them is usually much cooler than is the blood as it comes to the lungs. Thus the blood lowers its own temperature by giving up some of its heat to the air.

Heat and Animal Activity. — Emphasis is laid on the means provided for disposing of excess heat because in the case of man and of all active animals the activities of life, especially the working of the muscles, produce more heat than the body needs under ordinary conditions. When a boy is riding a bicycle rapidly, he is probably producing four to six times as much heat as when he is asleep; so there must be thorough and prompt provision for taking care of a large amount of extra heat.

It is equally necessary that sufficient fuel food to produce heat should be taken by man and all the active animals (called warm-blooded animals). If there is shortage of such food, the body may use its stored-up fat for a short time; after that the body heat must begin to drop and death will soon follow. When we say that a man or an animal died from "starvation," it usually means that death came because the body temperature could no longer be maintained. Lack of food does not so quickly produce trouble if one has warm clothing, for with warm clothing the heat of the body can be more easily maintained.

Inactive and Hibernating Animals. — Animals like frogs and snakes need much less food than others, because they do not use it to maintain their body temperature; their bodies are not kept warmer than the air about them. On a cold day their bodies are cold, on a hot day they are hot. These animals will usually be more active on a warm day, but all their vital processes go on properly no matter what their temperature is. They are called *cold-blooded animals* because they usually feel cold when we touch them, since our bodies are always

about 98°, which is warmer than these animals are during the greater part of the year.

Bears and some other warm-blooded animals have a peculiar way of meeting the difficulty of getting sufficient food during the winter. When winter comes, they go to sleep in their dens and often stay there until spring. During this long time without food the body temperature falls quite low, but it does them no harm, for they are able when they wake to restore quickly the normal heat of the body by burning the excess fat that was stored up in the fall for that purpose. They are called *hibernating* (wintering) animals because of their peculiar way of getting through the winter season.

Cooling by Evaporation. — There are two conditions under which a man perspires freely — on a hot day, and when he is doing hard muscular work. In both these cases much more heat is being made than the body needs, and profuse perspiration starts; it may even stand out in drops. If nothing else happened, the body would not be cooled. It is the evaporation of the sweat that causes the lessening of the temperature. The evaporation of water requires much heat; hence as the water on the skin is evaporated by the heat of the blood circulating through the skin the blood loses a considerable quantity of heat and the body becomes cooler. It is estimated that by means of perspiration alone the body is able to get rid of three times as much heat as it requires.

Keeping the air stirring greatly aids evaporation. On a very hot day we are much more comfortable if the wind is blowing, because evaporation is then more rapid. A hot, " muggy " day is even more uncomfortable than a

hot, breezeless day, for the moisture in the muggy air delays evaporation.

Importance of the Sweat Glands. — Were it not for the sweat glands we should have to make great changes in our habits of life as soon as the hot weather came. If we did not perspire then, we could not work because the other two methods of cooling the blood could not cool it sufficiently, if unaided. This was demonstrated in the case of a man, born with an imperfect skin, who had no sweat glands. This man was not able to do any work in hot weather, for as soon as he exerted himself his temperature began to go up, and he was soon in a state of "fever," and became really ill if he kept on trying to work. His body could not give off enough heat through the lungs, or by sending the blood rapidly to the skin, to keep his temperature normal, and having no sweat glands, he could not perspire.

Notice the difference between horses and dogs in hot weather: the horse perspires freely, the dog has fewer sweat glands and has to cool his blood by rapid breathing, *panting*. Some people perspire freely, some do not; other things being equal, the more freely a man perspires the less he feels the heat. Some men cannot for that reason work as stokers; they do not perspire enough to enable them to endure the great heat of the place where their work must be done.

Life at Heat above Boiling. — There is an excellent illustration, more than a hundred years old, of the ability of the body to keep its proper temperature in the midst of great heat. Some adventurous scientists tried to determine by experimenting on themselves the

effect of very high temperatures. They finally went into a room where the thermometer stood at 260°, which is 48° hotter than the temperature at which water boils. The heat was certainly great enough to burn their skin (and that is what might have happened to the man who had no sweat glands), but they were able to remain there for some time. The air they were breathing was hot enough to cook in twenty minutes the raw meat and eggs they took into the room, and the metal buttons on their clothing became so hot as to burn their fingers. In that temperature the men were very uncomfortable, it is true, but the prompt and profuse action of their two and a half million sweat glands made it possible for them to come out of the room uninjured; and it is highly probable that if use were made of all modern appliances for keeping air in constant motion, and so hastening evaporation, even greater heat could be borne for a short time.

Although heat is the usual cause of perspiration, it may start because of some sudden emotion, of fear, or of embarrassment; pain also may have the same effect.

Deceptive Temperature Regulators. — No matter how warm we may feel, we are actually losing heat whenever the blood vessels in the skin are opened wider than usual. When certain substances, like alcohol, are taken into the stomach, the blood vessels enlarge, the skin becomes flushed, and the body feels warm. Some people actually take alcohol on a cold day to keep them warm. They are being deceived by their feelings, for it does not and cannot warm them. The person feels warmer because the skin is heated, but in fact he really is losing body heat more rapidly than before.

Many instances might be given. One striking experience is that of a party of travelers who were obliged to spend the night upon an exposed place in the mountains. The cold was intense, and they had little protection from it. Some of them took alcoholic drinks to prepare themselves, as they supposed, to endure the cold, while others did not. Those who drank soon *felt* warmer because their warm blood began to flow through the skin, but before morning all those who had taken the alcohol had died from the exposure. Those who did not drink the alcohol suffered more from the cold, at first, because the warm blood was kept within their bodies, but they were able to endure the experience and were none the worse for it.

Men who go to the far north, on whaling expeditions or for exploration, used to suppose that alcohol was needed to help meet such exposure. Then science discovered the way alcohol acts, and that the warmth it seems to give is not real but deceptive. So explorers have learned the lesson, and now those whose lives depend for months at a time upon their being in condition to do much hard work, and to stand all kinds of exposure, seldom risk the use of alcohol.

QUESTIONS

1. What happens when a blister forms? Why is the skin under a broken blister so sensitive?
2. In what part of the body is the skin thickest? Why? In what parts is it most loosely attached to the underlying muscles? Most closely attached?
3. What happens to the skin when we exercise vigorously? Where do we feel warm?

4. What would happen if all the sweat glands of the body were closed?

5. How much warmer is a healthy body in summer than in winter? Why do we sweat more in summer? What effect does this have on the body temperature? Why does a dog "pant" in warm weather?

6. What is it that makes wounds and serious burns so dangerous?

7. How do we know when the air is warm? Why does a nurse test the temperature of water with her elbow instead of using her hand? Why does a woodsman moisten his finger and hold it up to know which way the wind blows?

8. Why do we feel cooler on a windy day than on a still day even when the temperature is the same?

9. If the skin did not regulate the temperature of the body, what would happen when the weather changed suddenly? Why do we wear more clothing in winter than in summer? Why do we need more when sleeping?

10. What happens to the temperature of the body when a person has a fever? How does the doctor "take the temperature"? Why does he not test it by placing the thermometer against the hand or cheeks?

11. Why should we avoid drafts when we are overheated? How may we get cooled off without danger of cold?

12. Why does a boy riding a bicycle feel cool while moving and warm when he stops?

13. What is the difference between warm-blooded and cold-blooded animals? Name examples of each class.

14. What relation does our food have to the temperature of the body?

15. Place the back of your hand on a cold windowpane and then the front of the hand. In which case does more moisture collect? Why?

16. An expressman, on a cold day, was invited into a house to get warm. "No," he replied, swinging his arms, "it is better for me to get warm this way." Give the reasons for his answer.

17. Why does one feel the cold more when going out immediately after eating? Is his body temperature lower?

CHAPTER XII

TAKING CARE OF THE SKIN

MANY boys and girls regard the daily bath, which is demanded by consideration for themselves and others, as an unmitigated nuisance. On the other hand, experience has taught army commanders that bathing is one of the best protections against disease, and that a clean skin is a safeguard against infection from wounds. Laziness and scrupulous cleanliness must have many a combat before a young person's habits are fully formed; but the daily bath surely ought to win the conflict since its advantages are so many and so obvious.

Why We Bathe. — 1. *The skin is cleaned.* The waste matter that the body gives off through the skin has an offensive odor, and if allowed to remain on the skin, the odor of the body will become perceptible and unpleasant to those around us, though we ourselves are unconscious of it. Surely no one wishes his body to be unpleasant to his friends, and the best way to prevent that is to remove the waste material by frequent bathing, which leaves the skin sweet and clean. If for any reason a daily bath is not feasible, a hard rubbing of the skin with a coarse towel will remove much of the waste matter and may answer as an occasional substitute for the bath.

2. *The skin is stimulated.* In the skin there are

thousands of tiny muscles that control the small blood vessels; these muscles should get their stimulus to action from the contact of the skin with cold air and hot air. In cold weather all the skin, except that of the hands and the face, is generally covered with clothing. As a result it is constantly kept so warm that these muscles fail to get their proper exercise, and so they become sluggish as any other muscles would. A bath gives these muscles the exercise they need, and for this purpose a cold bath is more effective than a hot one. However, if a hot bath is followed by rubbing the body with a towel wrung out of cold water (when a cold shower cannot be taken), the effect is good.

3. *It is a protection against colds.* The daily cold bath is almost a sure protection against colds. The skin learns to adapt itself readily to sudden changes in temperature that might otherwise cause a congestion of the air passages and thus give the germs there every opportunity to produce a cold or some more serious ailment. Putting cold water on the face, neck, and shoulders every morning helps to fortify the organs which are usually attacked by a cold.

Cold Baths. — A vigorous person gets real exhilaration from a cold bath: some can take a cold plunge every morning and feel better for it all day; others thrive better when they take a cold shower bath; others find that a cold sponge bath suits them better. Every one takes the beginning of a cold sponge when he washes his face in cold water, and cold water ought always to be put on to the face because it is so much better for the complexion. Those who are not used to taking cold baths would do

well to begin them gradually. Day by day a larger surface of the body may be treated to the cold sponge; then when the body is accustomed to the effect of cold water, a cold shower or plunge may be tried.

In a cold bath, the first sensation is one of cold, and the result is that the blood vessels of the skin contract, leaving the skin white and cold. Soon comes what is called the *reaction;* the blood vessels open and allow the warm blood from the interior to flow rapidly through the skin. There is a feeling of exhilaration, and the skin becomes flushed and warm. Before this glow passes, one should leave the water, for if he stays longer, he becomes chilly again, and may remain cold and uncomfortable for hours. One must determine the time by experience, for much depends upon the person, the temperature, and the water; the glow lasts longer after a bath in salt water. Vigorous friction of the body with a rough towel after the bath will increase the glow and the benefit derived.

Hot Baths. — From the ordinary hot bath the body gets none of the good effects that come from a cold bath; the muscles attached to the blood vessels get little exercise and there is no exhilarating reaction. A hot bath is beneficial, however, whenever it is desirable to call the blood to the surface of the body. If one is restless and wakeful at bedtime, a hot bath will draw the blood from the brain; if one has symptoms of a cold, a hot bath may draw the blood from the throat and nose sufficiently to prevent the cold from developing; in case of fatigue a very hot bath relaxes the overstimulated parts of the body. An occasional hot bath is also de-

sirable for the thorough cleansing of the body, even when a cold bath is taken every day.

Cold baths are stimulating and invigorating and are most valuable in the morning, just after rising.

Hot baths are not invigorating and should generally be taken before retiring at night.

Tepid baths are useful for cleansing the skin, and as they have no other effect upon the body they may be taken at any time.

Baths for Special Purposes. — Various kinds of baths are sometimes used for special purposes. In a *steam bath* the person is immersed for some time in hot steam, as hot as he can bear it. *Mud baths* we hear of occasionally, and various other warm substances may be used to give different types of *thermal* (heat) baths. There is a modified form of bath, called a "pack." Here the person, or a part of his body, is wrapped closely in wet bandages, sometimes hot and sometimes cold. If one is kept wrapped up in this way, the "pack" causes the blood vessels of the skin to enlarge, thus relieving internal congestion. A cold "pack" put on at night around the neck is an excellent remedy for hoarseness or a sore throat. All these types of special baths are used chiefly for persons who are ill, and they are commonly taken under the advice of a physician.

Care in the Use of Towels. — Each member of a family should have and use his own towels. Many cases of certain diseases of the skin and of the eyes have been traced to the use by others of a towel that has been used by some one who had the disease. Nor is it sufficient to take precautions only when we see the need

for them, as when we are with a person who has some skin eruption, for instance. Germs of various diseases may pass, as we have learned, from one well person to another, producing disease in the second person but not in the first; so individual towels and other toilet articles are important. Even greater are the dangers that may lurk unseen in a towel placed in a public building or conveyance for the use of all comers, sick and well, cleanly and uncleanly.

Care of the Hair. — Frequent brushing of the hair is not only necessary to a tidy and pleasing appearance, but it also helps to keep the natural oil distributed over the hair. A soft brush and a rubber or bone comb should be used; wire brushes and metal combs are too harsh. Nobody would think of using a public toothbrush. The use of a public comb or hairbrush is almost as dangerous. Since the hair is frequently exposed to the dust, there are likely to be disease germs on it, and there are also special diseases of the scalp, some of them highly contagious, that are easily spread through germs left on comb and brush.

Falling Hair. — The fact that the hair sometimes falls out is well known, yet little is actually known about the cause of falling hair or the remedy for it. Any simple means of increasing the circulation in the scalp, like pinching or rubbing it gently with the fingers, will help to nourish and strengthen it. Keeping the scalp clean, by washing it once or twice a month in water and some pure soap, is also a good habit. There can be no doubt either that "toning up" the general health will help to keep the hair growing vigorously. But why children's hair grows

thin, at times, and why men have a tendency in middle life to grow bald — those are questions which cannot be answered with any certainty. There are many theories, but none of them has proved itself.

Care of the Nails. — Long before men discovered how many disease germs might lurk in the dirt beneath finger nails, fastidious people took pains to keep their nails clean and shapely. When we consider how many things we are constantly doing with our hands that affect the pleasure, comfort, or health of other people, we can see that they have a right to expect us to keep hands and nails clean and tidy. Dirt should be removed from under the nails every time the hands are washed. The nails should be trimmed at the ends, with scissors or file; neither the surface of the nail nor the skin covering the root should be scraped.

Some children form the bad habit of biting the nails. This is likely to injure the shape of the fingers, besides being disagreeable to others. The habit can be overcome if one simply makes up his mind to control it; the will needs exercise to strengthen it just as much as the muscles do. The boy or girl who is going to be a success in life must be able to do hard things when they are required. Breaking bad physical habits, like this one, gives the will excellent preparation for meeting the demands of life.

The Choice of Clothing. — We wear clothing (1) for comfort and adornment; (2) to keep in the body heat, and to prevent its passing off too rapidly through the skin. For comfort in winter, it is necessary to cover the body with heavy clothing; in summer, the less

clothing we wear the more comfortable we are. Clothing in itself does not warm the body, but different kinds have quite different effects upon the body heat. Materials that carry off heat rapidly (called "good conductors") will cool the body quickly, while materials that conduct heat slowly will help the body to keep warm.

Linen carries heat away very rapidly, cotton less rapidly, while woolen is the poorest conductor of heat. Hence in warm weather, when we want to reduce the body heat, linen and cotton are the best materials for clothing, while in cold weather, when we want to retain the heat in the body, woolen clothing should be worn. People used to think that closely woven, firm cloth was the warmest, but it has been discovered that the air-filled spaces in cloth are very poor conductors of heat; so clothing made of coarsely woven cloth is really the best for keeping the body warm in cold weather. Similarly, two light garments, worn one over the other, are warmer than a single heavy one of equal weight, for the air space between the two garments acts as a non-conductor of heat.

Many people, especially those who do not take a cold bath every day, complain that a woolen undergarment worn next the skin irritates and gives much discomfort. A simple remedy is to wear a cotton garment next to the skin, and a woolen one over that. For people who are indoors most of the time this is an excellent combination of materials. When they perspire, the cotton readily takes up the perspiration, leaving the skin dry, and the layer of woolen next to it gradually absorbs and holds the moisture without borrowing the body heat; for

woolen can absorb a large amount of perspiration without becoming wet, while cotton and linen cannot.

Why Wet Clothing Is Dangerous. — The chief disadvantage of wet clothing is that it carries the body heat away too rapidly, the water in it being a very good conductor. Even in summer this is undesirable, for a person may take cold on a warm day from sitting still when his clothing is wet with perspiration after vigorous exercise. So long as one is active there appears to be little danger from wet clothing, even when it is soaked from rain, or from a fall into the water; for if one is moving about actively, enough more body heat is generated to compensate for the heat carried off by the wet clothing.

Cold Air Is a Tonic. — Most persons wear an unnecessary amount of clothing in winter, especially when they "bundle up" to go out of doors. If the thermometer goes below zero, special precautions must be taken; in ordinary weather there is no occasion for covering the face with veils and the neck with furs. We are much better off if we can accustom these parts of the body to the cold. Cold air produces the same glow that comes from a cold bath; there is tonic in it for the air passages. Cold air is much better for the throat than a layer of fur wound tightly around it, for this protection weakens the throat and makes one more likely to take cold.

To go to the other extreme would be equally foolish. Shivering when one first goes out into the cold is good exercise for the muscles and so produces a little extra heat, but the shivering ought to be followed by an exhilarating reaction; to shiver through a five-mile walk means either that one is not walking fast enough (running

a bit would help warm the body), or that the clothing is not sufficient to enable the body to retain its heat.

Extra Protection for Exposed Parts. — Our bodies really live in the temperature of the air that is between the clothing and the skin. In cold weather the clothing worn out of doors ought to be sufficient to keep the temperature of that inner layer of air at about 80°. When extra clothing is required, the arms, legs, and feet need more protection than the rest of the body because they are more exposed to the cold and less able to resist it, the circulation in them being less active than in the trunk of the body. Warm stockings and stout shoes are needed in cold weather, with rubbers whenever there is danger of wetting the feet. We may take cold from sitting still with wet feet, because the heat is carried off by the moisture faster than the sluggish circulation in the feet can replace it. Rubbers should always be taken off when one goes indoors; otherwise they would prevent the natural perspiration from passing off as it should. (Remember what happened when you closed your fist tight and held it so for a number of minutes.)

Keeping Warm during Sleep. — At night people are likely to keep the air in their sleeping rooms too warm. We rest much better when we are breathing cold, invigorating air, but we must be warmly covered. The body should do the least possible amount of its regular work during sleep, and when we "sleep cold," it is required to do an extra amount of work to keep up the absolutely necessary degree of heat. The brain needs rest too; if we are warmly covered while we are asleep, the part of the brain that is charged with maintaining the heat of the body

can rest, since little body heat need be made if the bed covering is sufficient to help retain what the body has. Sometimes it is not possible to get sufficient bed covering in cold weather, but newspapers are easily obtained, and a few thicknesses of newspaper placed firmly between two thin blankets or quilts will make a good covering for holding in the body heat.

The drop in heat production during sleep was amusingly illustrated in a series of experiments upon a young man shut up in a large copper box, to which were attached various appliances for measuring the amount of heat made by the body, the amount lost, etc. He was closely watched all day; and the comrades who were reading the different recording appliances knew how much heat he produced when he did certain kinds of work, how much when he studied, etc. When night came, he went to sleep at his usual time and the watchers were surprised to see that the amount of heat produced in his body began to decrease rapidly; the record went down, farther and farther, until they became thoroughly alarmed. Fearing that something had gone wrong in the copper box and that their comrade was dying before their eyes, in his sleep, they woke him, to find that he was perfectly well, and that the alarming decrease of heat was only natural when the body was sleeping under the right conditions.

The Use of Hot Water. — When we feel cold, the best way to get to feeling warm is to take some exercise which will send the warm blood coursing through the skin; that is the way nature has planned to give us the sense of being pleasantly warm, by having warm blood passing

over the tiny sense organs in the skin. Another way is to apply heat to the outside of the skin; a hot water bag or hot flatiron are most commonly used, and they serve a good purpose when applied temporarily. They warm the skin and also draw the blood from the over-supplied or congested interior of the body to the surface, thereby reducing the congestion. Congestion frequently causes severe pain, which such hot applications often relieve. No outer heat, however, can take the place of body heat; and if one is accustomed to getting warm at a hot stove or by means of a hot water bag, then the skin after a little fails to do its duty, and the person becomes unduly sensitive to cold and unable to resist and to enjoy it as he should. External heat should therefore be applied to the body only for the temporary relief of some unusual condition.

QUESTIONS

1. What effect does a hot bath have on the temperature of the body? On the skin? What effects do cold baths have?
2. What happens to us if we do not bathe sufficiently?
3. Why do all up-to-date gymnasiums have baths attached? Are there any public baths in your town? Are there any swimming pools? Do you ever bathe in them?
4. If you take a hot bath and then go out into the cold, how are you apt to feel?
5. Should baths be taken either immediately before or immediately after meals? Give reasons for your answer.
6. If a person catches cold easily, would you recommend warmer clothing, or cold baths? Give reasons for your answer.
7. Why does your mother put a cold bandage around your throat when you have a cold?

8. Why do barbers apply hot and cold towels to the face after shaving?

9. Why is it unwise to use towels that have been used by any one else, even if the other person is perfectly well?

10. Is it wise to use the combs and brushes of other people? Give reasons for your answer.

11. How can you stimulate the growth of the hair? Do you know what to do for hair that is too dry? Too oily?

12. Why is it better to clean the nails with a soft orange stick than with a steel file? Do you ever push back the cuticle of your nails? Why should you do this?

13. Besides improving the appearance of the nails, can you think of any reasons why it is well to stop biting them?

14. Why do we wear clothing? If you wrapped a piece of wood in thick woolen cloths, would the wood become warm? Give reasons for your answer.

15. Compare the effects of wearing clothing of cotton, linen, and wool, (*a*) in summer and (*b*) in winter.

16. If two boys, one barefoot and one wearing shoes and stockings, get their feet wet, which is more apt to take cold? Why are your feet apt to be cold when they are wet?

17. Why do you shiver when you go into a cold place? Is there any advantage in shivering?

18. If a person spends most of his time indoors, how should he dress, (*a*) when in the house and (*b*) when he goes out?

19. Is it wise to go to bed with cold feet? Why not? Which is better, to warm them by taking a hot water bag to bed, or by slapping and rubbing them?

CHAPTER XIII

SKIN DEFECTS AND DISEASES

Common Skin Defects. — Sometimes the skin gets much thickened at certain places. Boys are proud of a *callus* (callosity) on their hands, caused by ball playing or by rowing; the rubbing of the oar and the striking of the ball make the epidermis on the hands grow more rapidly and so it becomes thicker. This is nature's way of protecting against injury.

Corns on the toes are formed in the same way; a tight shoe or an ill-fitting one that presses too much on certain parts of the toe produces a decided thickening of the skin at those spots. The result is that when the pressure comes on the thickened parts, they do not readily yield; so the soft inner skin is pinched and walking becomes more or less painful.

It is much easier to prevent the formation of corns than it is to get rid of them. Young people who wear shoes that are large enough not to pinch the toes, and yet snug enough not to chafe the feet, need not fear corns. Children who go barefoot in the summer do not have them, nor do they have the misshapen toes that are common in these days when so many people choose their shoes because of their attractiveness rather than with reference to the shape and size of their feet. If you are unfortunate enough to have corns, they may

be kept from increasing in size and from becoming painful by wearing corn girdles or plasters that may be purchased at the drug store; these prevent the pressure of the shoe on the corn.

Some people cut or shave their corns. This practice is really dangerous because a foot may be easily infected. If one cuts so close to the inner skin as to draw blood, then there is always the risk of infection from germs which may cause sores on the feet. Blood poisoning, with the loss of a toe, and sometimes even the loss of life, has resulted from the cutting of corns. If a corn has to be cut, it is best to go to a chiropodist or to a doctor, who will take every precaution to prevent trouble. When the hard outer covering is removed, the wearing of a corn plaster will make one comfortable for a long time.

Warts have, for some reason, always been regarded as mysterious growths; perhaps it is because they come and go without one's being able to determine what caused or banished them. Children sometimes believe the stories about warts being caused by handling toads or by touching the hands of those who have warts, and about their being driven away by "charms." This is all nonsense; but there is no doubt that warts will usually go away if they are let alone. It is better to let them disappear than to have them removed, unless they grow so large or are so located that they prove a great inconvenience; then a physician can burn them off with acid.

Blackheads are caused by the hardening of refuse matter in the tiny openings of the sweat glands. To prevent them the skin of the face should be kept active

and healthy by thorough cleansing and by continual washing in cold water; warm water relaxes the skin and is likely to leave the tiny openings too large, thus inviting the storing up of the dust that collects from the air, as well as the secretions thrown off by the skin.

Every one who is in good health should have skin that is smooth and soft. *Pimples* show that some organ of the body is not doing its work properly. The trouble is seldom in the skin itself. Frequently the cause is indigestion, and both it and the pimples pass away when one eats properly and takes the right amount of exercise. Often the only remedy needed is to eat less meat and fewer sweets and to chew the food more thoroughly.

Slight Burns. — Most slight burns are received by touching some hot object, like an oven door, an iron handle, or a bucket of boiling water; they may be very painful, but unless they are deep or extensive they will soon heal and be forgotten. They may be soothed by keeping them covered from the air, or simply by the application of cold water. One of the best coverings for an ordinary burn is a paste made from vaseline (or sweet oil) and soda (or baking powder). These are usually at hand and can be quickly rubbed together into a paste and applied to the burn before it has been long exposed. There are various substitutes that may be applied in an emergency, such as linseed oil, limewater, cold cream, or flour; the object is to cover the burn completely and to use nothing that will adhere to the wound as cloth or cotton wadding does. As in the case of a wound, a burn should always be treated with materials that are *clean.*

Serious Burns. — The most serious burns are caused

by coming in contact with flame, usually from setting the clothing on fire. That is the time when life may be saved by keeping calm and by doing one or two simple things. *Flames always rise;* and the greatest danger comes, not from the injury to the skin but from the inhaling of the flames, which is sure to cause death. So the first thing to remember is that instead of standing or running about, the person whose clothing is on fire should lie down on the floor. When on the floor he can do more to help himself than by running about looking for some one to put the fire out; and while he works he can be calling lustily for help.

His effort must be to smother the flames; fire cannot burn without air, and he can keep the air from the flames by wrapping about himself the rug on the floor or whatever heavy covering he can reach without running around after it — a blanket from the bed, a coat, a heavy drapery torn from the window, or an end of the carpet pulled up. If there is no woolen stuff or heavy covering within reach, the best thing to do is to roll over and over on the floor, as rapidly as possible; this alone will usually put out the fire.

The part of the bystander is to do what the burning man may forget to do. Knock him down if he starts to run. Remember that it is better to smother the flames in some woolen covering than to attempt to beat them out with the hands. After the fire is out, the clothing must be carefully removed. In case of severe burns the clothing will be apt to stick to the burned part; it should not be torn away, but should be cut off. Cover the burned places until a physician can decide what had

best be done. In the meantime, if the physician cannot come immediately, the burned surfaces should be covered with something, like the paste recommended above, that will keep the air out and that may be readily removed without injury to the burned skin.

Frostbites. — The ears, the nose, the fingers, and the toes are particularly susceptible to frostbite, which may be a mild form of freezing or the actual turning of the blood and muscles into ice. These extremities are not only more exposed than other parts of the body, but the circulation of the blood in them is much less rapid. We might expect that they would be the first to freeze, because we know that still water freezes more quickly than running water. In ordinary frostbites no permanent injury results if the frozen parts are thawed out slowly, but serious trouble may follow rapid thawing, even the necessity of amputating toes or fingers. Rubbing the parts in snow or in cold water is recommended. The rubbing will thaw the part, and the snow will prevent the thawing from taking place too rapidly. Evidently it would be unwise to place the patient before a fire or in a warm room, but he should be well bundled up in blankets while the frozen part is being gradually thawed. After thawing it should be covered to keep out the air, and in general treated as a burn.

Chilblains. — Frostbite is wrongly credited with being the cause of a painful ailment of the feet known as "chilblains." Getting the feet very cold and wet and then warming them too quickly is the most frequent cause of chilblains. One is laying the foundation for chilblains when he warms his feet over a register or in a stove oven,

or heats them every night on a hot water bag. The best protection against chilblains is to wear warm stockings and thick shoes in cold weather, and to give the feet plenty of exercise. The symptoms are a burning and an intense itching of the sides of the feet, the toes, and the heels.

Skin Infections. — It used to be said that boils, abscesses, skin eruptions, erysipelas, and blood poisoning were due to "the condition of the blood"; but since men have learned more about the action of microbes, most of these troubles have been traced to the entrance into the body of disease germs through the skin. The germs which cause most skin troubles are very much alike. They are found on our clothes, on our hands and faces, and in our mouths, but they do no harm until they get through the guard formed by the outer skin and enter into the blood or lymph. A bruise or even a scratch in the skin gives them entrance; what happens next depends upon the condition of the blood, that is, upon the ability of the white corpuscles to conquer the disease microbes.

If the microbes win the contest, a characteristic form of inflammation usually results from their growth. A good healthy body often has power enough to resist the ravages of these particular germs and to prevent their growing, even after they get into the body through the skin. If a person finds that every scratch becomes inflamed, if he keeps having boils, he may know that his body is warning him, as plainly as possible, that it has lost much of its power of resisting the attack of the germs that may get in through the skin. What he needs is,

not to get a skin lotion, but to follow the general laws of good health.

Bruises, cuts, and *scratches* are an invitation to the microbes, since they all make breaks in the protecting outer skin. They should therefore be promptly and carefully cleansed. The invading germs are easily disposed of in the beginning, but hard to fight when they get a start. All wounds should be treated with an *antiseptic solution,* either iodine or carbolic acid (one part to twenty of water), which will destroy the germs. It is always advisable to keep on hand a bottle of tincture of iodine or some antiseptic ointment, and to get into the habit of washing all cuts and scratches with it. Then when they are made clean, forget about them. Many troublesome sores may be prevented by this simple precaution. After the wound has been cleansed, it should be covered with a bandage of *clean* cloth to bar out the microbes in the air.

Deep wounds frequently do not bleed much, and so they may appear less serious than surface wounds that bleed profusely; but the slight bleeding is really a disadvantage, because germs are likely to be washed away from an open, bleeding wound, while those carried deeply into the flesh by a nail, or needle, or splinter may remain there and make serious trouble. The object that produces the wound should therefore be removed. This is sometimes a very difficult thing to do when a piece of glass or a long splinter is imbedded in the flesh, especially under the finger nail; but to leave it would mean danger. After it has been removed, the wound should be made to bleed freely, thus washing away as

many as possible of the dangerous microbes. Then the wound should be treated with iodine, and if possible some of the iodine should be injected into the wound, a hard rubber syringe being used for this purpose. A *deep* wound should have the care of a physician, and if one cannot be secured immediately, iodine should be used promptly.

Lockjaw. — A wound made by a rusty nail, or a dirty sliver of wood that has been lying on the ground, is likely to be dangerous. Rust does not produce lockjaw, but if a nail has been lying around long enough to rust, it has also had time to become the lodging place for many microbes. In some parts of the world the soil contains a deadly microbe which produces **lockjaw**. It is most common in soil that has been under high cultivation. Yet there are few places where one can be free from danger from these microbes; any dirty object may have some of them clinging to it. Toy pistols, whose sale many cities now forbid, especially on the Fourth of July, are particularly dangerous because a boy's hands are apt to be dirty from firing this pistol. By the explosion of the pistol the dirt may be carried into the skin, and perhaps with it the lockjaw (tetanus) microbe.

Lockjaw is practically *always* fatal, so that the only way to fight it is to prevent it. The best prevention is to make every deep wound absolutely clean by a daily antiseptic cleansing. A deep wound should not be allowed to heal at the surface because the lockjaw microbe, which cannot grow when exposed to the air, may thrive and become dangerous if tucked away undisturbed in a deep wound. A deep wound should be covered

constantly with a clean cloth, but should be kept open, for a time, at the surface. Since microbes may render even slight wounds dangerous, it is foolish to run about, carelessly, with sharp objects in the hands or in the mouth. Many young people have lost limbs or eyes because of simple carelessness with knives, scissors, and buttonhooks.

Cuts and bruises on the feet should be even more carefully treated than wounds elsewhere. They should be cleaned at once, washed with an antiseptic solution, — iodine is the best, — and then they should be firmly covered with clean cloth before the stocking is replaced. This will prevent many a sore toe and, perhaps, something more serious, like blood poisoning. The necessity for these precautions is evident when we realize that any sore on the foot, even a small break around a toe nail, is aggravated by being shut up in the shoe, and by the moist stocking continually rubbing against it. These are ideal conditions for the microbes, and the stocking is almost sure to harbor many disease germs which only need warmth and moisture in order to grow rapidly.

Fishhook wounds are usually quite shallow; if the barb makes it difficult to remove the hook, push the point through the skin; then the barb can be cut off with a wire cutter, and the hook, minus the point, is easily removed.

Bites of animals used to be considered dangerous, because of some mysterious poison that was said to be made in the mouths of angry animals. In fact they are more dangerous than ordinary wounds, but only because dangerous germs are usually lodged in an animal's mouth.

For the same reason the bite of another person is even more dangerous than the bite of an animal. An antiseptic wash should always be used in such wounds.

Rabies. — The bite of a dog is especially feared because it sometimes produces a much-dreaded disease called **rabies** or **hydrophobia**. This disease is one of the most painful and practically always fatal. But dog bites cannot cause hydrophobia unless the dog is at the time suffering from the disease. A rabid dog does not yelp or bark, and does not froth at the mouth, though a brownish mucus may hang from his mouth. He usually jogs along slowly through the streets, paying little attention to anything, but is likely to snap or bite if anything comes in his way. He does not dread water as is commonly believed. One such dog sometimes travels for many miles, biting many other dogs on his travels and thus giving them the disease.

Often a healthy dog is tormented or frightened until it tries to bite every one who goes near it; some boy gets too close and is bitten. Then, fearing the dog is "mad," somebody will probably propose that it be killed at once. This is a very short-sighted thing to do; instead, the dog should be shut up safely where it cannot bite people or other dogs and given food and a chance to recover. If really rabid, it will surely die within a day or two. *If it does not die, it was not a mad dog.*

Should it die, the head should be sent to some proper laboratory, where an examination will quickly show whether the dog really had rabies. Remember that the disease is uncommon. Dogs get it by being bitten by other dogs who have the disease; they are no more

likely to have it in hot weather (sometimes called "dog days") than in winter. Human beings get it wholly from animals, chiefly from dogs, though occasionally from the bite of cats or wolves, or even of skunks. Many absurd stories are told about this disease. Sometimes one hears that a person bitten by a well dog will have the disease if that dog should at any time afterwards develop it. This is sheer nonsense, for the germs of the disease must actually be in the animal's mouth when he bites, in order to produce the disease. How many people do you know who have ever seen a mad dog?

Any one who is bitten by a dog that is really rabid or that is strongly suspected of being rabid should be taken at once to a Pasteur Institute, where he can be given a treatment that will usually prevent the development of the disease. This treatment cannot be given by an ordinary physician, and it must be begun quickly. If delayed more than two or three days after the person is bitten, there is much less chance of preventing the disease; if it can be begun *at once*, it is almost sure to be effective.

Rabies would soon be stamped out entirely if all the dogs in the world could be muzzled for a short time, since it is only distributed by biting. England succeeded in getting rid of rabies by simply muzzling all its dogs.

Diseases with Skin Eruption. — The most common diseases that are accompanied by a skin eruption are **scarlet fever, measles, chicken pox,** and **smallpox**. Scarlet fever is a severe and sometimes fatal illness; the most serious feature of it is the effect produced by its poison on the kidneys and other internal organs. Measles also sometimes ends fatally. The skin eruption gives much

discomfort, and the eyes are often seriously affected. Chickenpox is rarely serious. The germs that cause these diseases are not yet known, but the infection probably passes from the nose or the skin of the patient.

All of these diseases are very contagious; the spreading of them can be avoided only by keeping those affected isolated until they can no longer convey the infection to others; that is, from two to six weeks, varying with the different diseases. Most towns and cities have regulations covering these and other contagious diseases, which are designed to prevent them from being carried from one person to another and becoming epidemic. All good citizens ought to be willing to follow such regulations. The nation has a right to expect that every citizen shall try to be *a well citizen.*

Smallpox. — In former times smallpox was a frightful scourge. It not only caused an immense number of deaths, but its victims who recovered were often made unsightly by the "pitting" of their faces. To-day it is placed in the class of preventable diseases; epidemics of it are rare because men know how to fight it. There are two factors in fighting it: (1) *isolation* and (2) *vaccination.*

People who have had smallpox are usually *immune* to it, i.e. they will not have it a second time; certain changes have taken place in the body which are a defense against the disease. The object of vaccination is to produce a similar condition and to make one *immune* to smallpox but without having the disease. This is done by scraping off a bit of the outer skin of the arm and touching the live skin with a "point" that contains the virus

of cowpox, a very mild form of smallpox. If the virus "takes," the person vaccinated usually has a slightly sore arm, generally not sore enough to keep him from work, and his blood is temporarily made *immune*, not only to cowpox, but also to smallpox. This immunity lasts from three to ten years. In countries where vaccination is enforced by law the number of cases of smallpox is small. Physicians who are treating smallpox patients are themselves vaccinated every few years, and it is seldom that one of them takes the disease. Smallpox has practically disappeared from countries where every one is obliged to take this precaution.

QUESTIONS

1. Have you ever had callous spots on your hands or feet? If so, what caused them? Did they hurt? How did you get rid of them?
2. If a corn is composed of dead skin, what makes it hurt? Can you think of any reason why a person who suffers much from corns is likely to suffer also in his general health?
3. Why do doctors tell you to treat a bad complexion "from inside" instead of depending on salves and ointments?
4. What is the cause of most skin diseases? In clearing the skin of imperfections, what are the most important things to do? Can one person give such diseases to another?
5. Why does not the doctor in the laboratory, who is continually handling disease germs, always contract the disease?
6. When disease germs get into the body, what part of the body has the duty of getting rid of them? Do the white corpuscles always win in the fight? If not, what happens?
7. Can you think of any reason why it is a law of nature that cuts and bruises should hurt?
8. What should always be done when the skin is cut or scratched or burned? Why should one take special care of wounds on the feet?

9. What is meant by an antiseptic? What antiseptic have you in your home? Do you know where it is kept and how to use it? What is meant by a sterile bandage? How is a bandage sterilized?

10. Why does a doctor wash his hands so carefully before treating wounds? Why is a dirty wound more dangerous than a clean one?

11. What is the most important thing to remember in case of fire? If the clothing of a pupil in your class should catch fire, what would you do? What would you use to put out the fire? If the fire happened in your own living room, what could you use?

12. Why is it that bad burns are so dangerous? What must you remember in treating burns? If some one in your home should be burned, do you know where to find the things needed for treatment?

13. What parts of the body are most apt to be frostbitten? Why? Why should not frostbitten people be brought into a warm room? How should they be cared for?

14. Have you ever had chilblains? Do you know what causes them? What can one do to avoid them?

15. Why is lockjaw so dangerous? How can the germs of lockjaw be carried into the body?

16. Is there any law in your town or state forbidding the sale of toy pistols? Why is a toy pistol dangerous?

17. If you were bitten by a strange dog, what ought you to do? How can a doctor find out if a dog really was mad? If you see a dog that you think is mad, what is the best thing to do?

18. Why is it that children who have measles, scarlet fever, etc., are not allowed to go to school even if they are not very sick?

19. Are there any laws in your town forbidding children from homes in which there are contagious diseases, from going to school?

20. Why do most cities require that school children shall be vaccinated? Is there as much smallpox now as there used to be?

SECTION III

HOW THE BODY IS GOVERNED

CHAPTER I

THE GOVERNING MECHANISM

The Need of Direction. — The different parts of the body could never do their work properly if they were not directed by some central authority, which relates one to the other and decides which of them may, at any time, have extra blood, when each shall rest, and when each shall work. Just imagine what chaos would result if the organs were allowed to direct their own work. The stomach might secrete all its juices and do all its churning at night, when there was no food to digest; the muscles might start to get their work for the day done early in the morning and later be too tired to carry us about; the heart might try to work on the stomach's schedule, two or three hours of continuous work followed by an hour or two of rest: there is no limit to the accidents that might occur if every part of the body were not held to strict account by some central authority which told it just when to do its work and how.

The Neurons

The Individuals That Compose the Nervous System. — The government of the body is controlled by the **nervous**

system, which is like a highly organized army. The individual soldiers composing this army are called **neurons.** They cannot be seen without the microscope. Figure 79 shows how they look under the microscope. Near the center there is an irregular-shaped body, containing within it a smaller body, called a **nucleus**. From the neuron body a few branches are given off, each of which soon divides into numerous fine branches, called **dendrites** (really much finer than those shown in the figure). One of the branches, instead of dividing, extends away from the neuron body undivided, and finally, as a **nerve fiber**, joins other nerve fibers to form a nerve trunk. The nerve fiber may be very long or very short. The longest nerve fibers are those extending to the toes; these have their beginnings in neuron bodies somewhere up in the spinal cord. The one long branch of a neuron is called its **axon.**

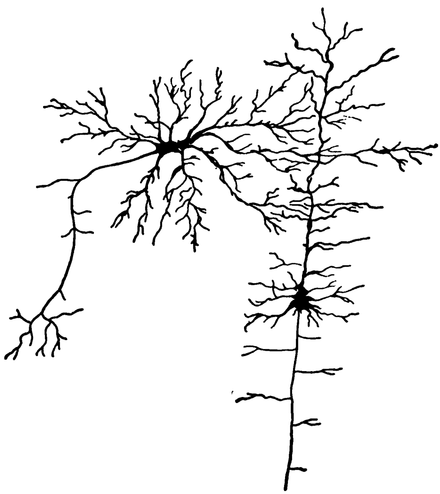


FIG. 79. — TWO NEURONS.

The neuron army is a big one indeed, for there are some 9,000,000,000 neurons in the brain, each with its dendrites and its axon. That explains why it takes years to get this army properly trained, and why children have

to spend so much time in school; for studying is one of the chief means of training these brain soldiers to do their work.

When we speak of the work done by the nervous system we are really speaking of the work of neurons. Tiny as they are, each has its own work to do, and each may call upon the others for help or direction if necessary.

The Duties of the Neurons. — These tiny neurons really control all the actions of the body. One of their principal duties is to control the muscles by giving them orders. Each muscle fiber has a nerve fiber (an axon) attached to it, the other end of which is in a neuron body somewhere in the spinal cord or brain. The neuron in the brain gives an order which travels down the nerve fiber, at the rate of about 100 feet per second, till it reaches the muscle fiber; the muscle obeys by contracting. But it is not muscles alone that are controlled by neurons. The secretion of the glands, the circulation of the blood, and even our sensations and our thinking are regulated by neurons.

The Organization of the Neurons. — Individual soldiers do not make an army until they are properly organized; this is equally true of the neurons. The organization of an army is so much like that of the nervous system that it will help us to understand this system if we consider how things are arranged in an army. Starting at the top, we shall find that an army has a commanding general who makes the plans for the whole army. This general does not have time to give commands to the individual soldiers; he has many subordinate officers

who attend in different ways to the carrying out of his plans. There are majors, captains, and lieutenants, each in charge of bodies of men, and below these are the sergeants and corporals, each with his subordinate share in carrying out the plans of the commanding general. Finally there are the soldiers themselves, each with his particular duty to perform. In a well-drilled army each soldier and each officer has learned his duty and his relation to all the others, so that the orders of the general are instantly and efficiently carried out. Such a well-organized army can win victories.

FIG. 80. — THE NERVOUS SYSTEM.
Showing the brain, the spinal cord, and the chief nerves.

Now while this illustration cannot be carried out in every respect as applied to our bodies, it does give us a good idea of how the duties of the nervous system are divided. We might make the comparison as follows. (It is for reference only, not to be learned.)

Commanding general	Cerebrum	Brain
Major officers	Cerebellum	Brain
Quartermaster (in charge of supplies)	Medulla	
Petty officers	Spinal cord	
Common soldiers	Neurons	
Sentries and scouts	Sensory nerves	
Messengers to carry orders	Motor nerves	

The nervous system is really a much more complicated organization than this; moreover, we must remember that the cerebrum not only contains the commander in chief but also countless numbers of the individual neuron soldiers. Yet in spite of these differences the comparison very well suggests how the different parts of the nervous system are related. Let us now see what these parts are.

The Cerebro-spinal System

The Cerebro-spinal System consists of three parts:

Brain
Spinal cord
Nerves

The Brain. — The brain is one of the most complicated structures in existence. It is also one of the most delicate organs in the body, and for protection it is inclosed in a bony box called the skull. It can never be observed directly except in cases where through some accident part of the bony covering is removed. It weighs about three pounds in a grown person, being approxi-

mately $\frac{1}{44}$ of the entire weight. Other animals have brains of greater or less size, but even the most intelligent of them have brains that are either much smaller than man's, or smaller in proportion to the weight of their bodies; the brain of the elephant is $\frac{1}{747}$ of his weight, that of the chimpanzee $\frac{1}{80}$ of his.

The brain is divided into three parts. These three parts are no more separated from one another than are the arm

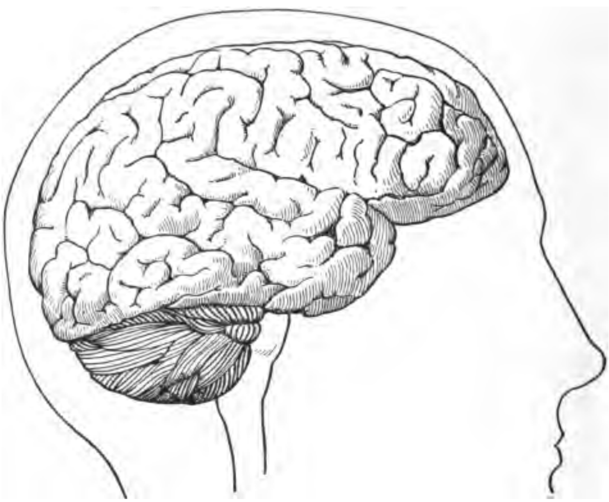


FIG. 81. — THE HUMAN BRAIN.

and the hand, but as their structure is different and their work different it is easier to consider them separately. These parts are called the cerebrum, the cerebellum, the medulla oblongata.

The Cerebrum. — The largest part of the brain is the **cerebrum**, it being seven-eighths of the entire brain. Its

surface is deeply folded. The folds are called **convolutions**, and the deeper the folds the greater the brain power of the individual. Some animals, like frogs, snakes, and birds, have practically no brain convolutions; but they are found in the higher animals, like monkeys, though they are not so numerous or so deep as those in a man's brain. There is a very deep furrow in the cerebrum which divides it into two (connected) halves, called the **right hemisphere** and the **left hemisphere**. Here we discover one of the brain's many surprises, for the right hemisphere proves to have charge of the left side of the body, and the left hemisphere of the right side of the body.

The cerebrum looks gray, for the outside of it, to a depth of about three-sixteenths of an inch, consists of countless neurons massed together, making what is called **gray matter** (Figure 82); below that is **white matter**, which consists of a mass of axons. We already know that there is a decided difference in the kind of work done by neurons and axons and in their methods of working. The mass of neurons which makes the outer surface of the cerebrum is, for convenience, called the **cortex**. It is the cortex that thinks, receives sensations, and gives orders that cause

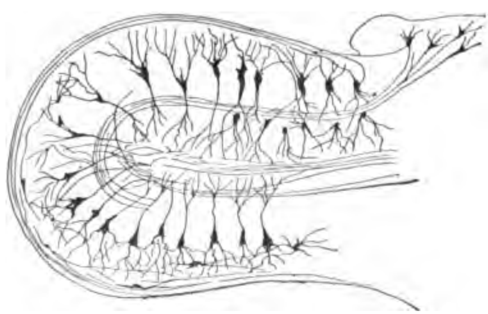


FIG. 82. — A BIT OF THE CEREBRUM.
Showing numerous neurons and their dendrites highly magnified.

movements in different parts of the body; all the conscious movements in the body are regulated by the cortex.

The Cerebellum. — Below the cerebrum and partly covered by it, is another part of the brain, called the **cerebellum**; it is not larger than a lemon, and has many furrows that go across it from side to side. One of its chief duties seems to be to relieve the cerebrum of the necessity of giving constant attention to the condition of the voluntary muscles. It takes many muscles working together to produce such a motion as throwing a stone, walking, or skating. The cerebellum makes all the muscles involved act in harmony, so as to produce the desired motion. We call this marvelous power *coördination.* The cerebellum contains some of the subordinate officers that produce this coördination. When the cerebrum wants the body to walk, it sends a message to the proper officer and then pays no further attention.

From observations on frogs it is thought that most movements could be made by the cerebellum without the help of the cerebrum. The cerebellum of the frog could direct the motions involved in jumping from the shore into the water; but if the frog had no cerebrum, it would not try to jump unless some outside stimulus, like the pinching of a hind leg, started the motion. Otherwise, lacking the cerebrum which usually gives the cerebellum its commands, the frog would just sit on the bank and die, able to move but lacking orders to move.

The Medulla Oblongata. — The cerebrum and cerebellum are connected with the spinal cord by the **medulla oblongata.** This is only three-fifths of an inch thick, and about an inch long, yet this small part of the brain is

absolutely indispensable to life, not simply because it connects the brain and the cord, but because it has important work of its own to do. It controls the heart-beat, the contractions of the blood vessels, and breathing; without these functions life could not go on. Life of a limited sort can go on without the cerebrum and the cerebellum, provided that the medulla is still connected with the breathing muscles. This is proved by cases where an injury to the spinal cord has so broken the connections that the cerebrum and cerebellum have no longer any connection with the limbs or the trunk, although the breathing center was still connected with the breathing muscles. The injured man had no sensations in limbs or trunk, but he lived for years, and was able to think and of course to breathe, but not to move. The medulla has other duties also besides those mentioned.

The Spinal Cord. — We have already seen that the spinal cord is so protected by the vertebræ that it receives surprisingly little injury from falls, blows, or other accidents. The soft membranes that cover it also serve as another means of protection. The cord runs from the medulla to the end of the spine. In a person of average height it is seventeen inches long, three-quarters of an inch thick,

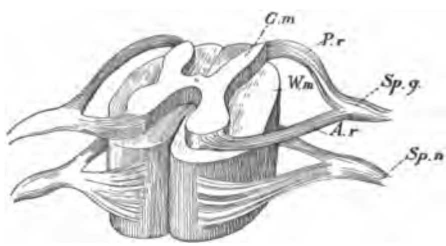


FIG. 83. — A SMALL BIT OF THE SPINAL COLUMN.

About four times natural size. *A.r.*, anterior root; *G.m.*, gray matter; *P.r.*, posterior root; *Sp.g.*, spinal ganglion; *W.m.*, white matter.

and weighs only about an ounce; yet in that ounce of spinal cord most rapid and delicate work is done. Like the cerebrum, it consists of both gray and white matter, but arranged in just the reverse order, i.e. white on the outside and gray within. Like the cerebrum, too, it is divided by a deep furrow which nearly separates it into two halves, giving it the appearance shown in Figure 83.

This figure also shows the gray matter (in shape not unlike a letter H) sending out four **nerve trunks**, which soon unite to make a pair of nerves, one going to the right side of the body, the other to the left. There are thirty-one pairs of nerves given off by this gray matter, and these nerves, with the twelve pairs of cranial nerves (from the brain itself), go to every part of the body. The white matter of the cord takes its orders from the gray matter, and like the nerves it does what it is told to do, as any well-trained private should. The white matter is really simply a bundle of nerve fibers.

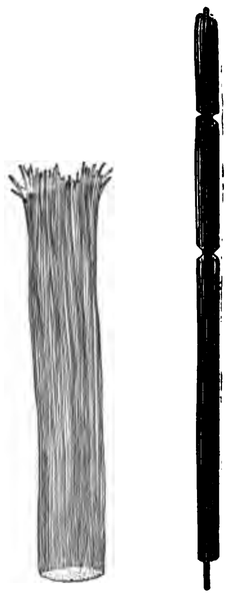


FIG. 84. — A NERVE. Showing that it is a bundle of fibers; also a single fiber more highly magnified.

Nerves. — Nerves look like white threads, some very tiny and some as big as a quill. They are slightly transparent and soft and delicate. Did your dentist ever show you a bit of a dead nerve of a tooth that had been giving you pain before he destroyed it? It

looks like a useless little bit of white marrow; nothing suggests that it is of any importance. The microscope tells a very different story; it shows that the nerves, after they leave the cord, may consist of thousands of minute threads or fibers (axons of neurons) too small to be seen without a microscope, and compactly arranged in bundles (Figure 84). These bundles branch as they go out through the body, the smallest parts of the body finally receiving some of the fibers. The number of these tiny fibers, running from the brain and cord over the body, literally reaches into the millions.

Sensory and Motor Nerves. — There are two different kinds of nerve fibers; they may go through the body in the same nerve bundle, but they always work separately, even when they travel side by side. One kind is always *carrying messages to* the cord (and perhaps on further to the brain); the other kind is always *carrying messages from* the cord (or the brain).

The nerve fibers that carry *to* the cord (or the brain) news of what is happening at their outer ends are called **sensory nerves.** We may think of them as sentinels or scouts reporting on what is happening at the advance line. When the cord or the brain receives a report from the sensory nerves there is usually something to be done about it. The nerves that carry the messages to the brain have nothing to do with this, however; their business is to make reports, not to carry orders.

From these reports the brain or the cord determines what is to be done, and the orders for doing it are carried by the **motor nerves**, which transmit these directions to the muscles with which they are connected. These motor

nerves never make reports about what is going on, nor do they ever cause a muscle to contract until they receive orders to do so. Each set of fibers has its own business and never is known to try to attend to that of its neighbor.

Nerve Trunks. — The nerve fibers leave the cord in two branches or **roots**, passing through a swelling, called a **ganglion** (see Figure 83). The branch at the back of the cord, called the **posterior root**, carries nervous impulses ("messages") from the skin or other organs to the cord and the brain. The front branch, called the **anterior root**, carries nervous impulses from the brain to the muscles. Beyond the ganglion the two kinds of nerves unite to form one nerve trunk, in which the sensory and motor nerves run side by side. Both kinds of nerves go to all parts of the body, some of them ever ready to tell us what is happening, others ready to make something different happen by telling the muscles to pull this way or that. The two kinds of nerves look so much alike that one could never tell them apart by their appearance; nor can one *see* how they work, any more than one can tell by looking at a telephone wire whether or not it is carrying messages. Like the telephone wire the nerves never *look busy.*

The Sympathetic System

The Work of the Sympathetic System. — There is another part of the nervous system, closely connected with the parts described and yet more or less independent of them. Its name, the **sympathetic system**, comes down to us from a time when little was known of the

way nerves work; it was then thought that this set of nerves served to bring into harmony the organs of the body that are distant from one another. Generally speaking, the sympathetic system is connected with the organs whose actions are involuntary, while voluntary actions are controlled by the **cerebro-spinal system.** There are exceptions to this rule, for some actions of the brain, which belongs to the latter system, are involuntary.

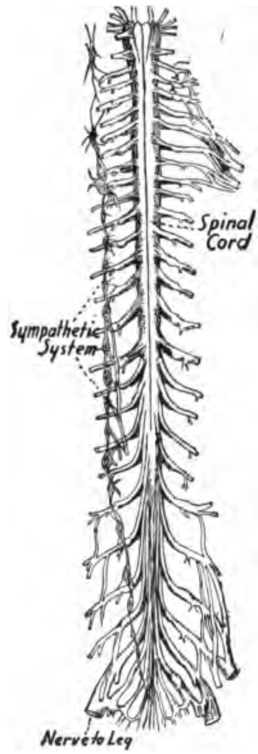


FIG. 85. — THE SPINAL CORD AND SPINAL NERVES.

On the left is shown the sympathetic system. There is a similar system on the right side of the cord, not shown in the figure.

The sympathetic system consists of two long nerve cords, or chains of nerve ganglia, one lying on each side of the backbone and in the back part of the body cavity (Figure 85). The two cords extend from the skull to the end of the spine. From the cords are given off many small branches which go into the organs of the abdomen, into the glands, into the blood vessels, and into other parts of the body whose actions are involuntary.

The Solar Plexus. — There is one part of the sympathetic system which is well known; it is called the **solar plexus.** This is a great mass of nerve fibers, mostly from the sympathetic system, that form a very com-

plicated network back of the stomach. This intricate mass of fibers has such a close connection with most of the organs in the abdomen that a "blow upon the solar plexus" acts directly on the nerves that control the vital organs, and immediately produces tremendous physical effects. Such a blow may throw the body entirely out of its normal condition by disarranging the stomach, the heart, and the breathing; it even disturbs the brain. The close connection between the sympathetic system and the cerebrum is also shown by the fact that one cannot use his brain when he is "sick at the stomach." Moreover, a dog cannot digest his dinner (neither can a person) when he is angry, though anger has to do with the cerebrum, while digestion is connected with the sympathetic system.

The Nervous System in Action

Coöperation among Neurons. — In a well-drilled army the soldiers are taught to act together, by companies or regiments, since by this means much more can be accomplished than if each soldier acts by himself. Our neurons are also drilled to act together. When a boy throws a stone he does not realize that he is using a wonderful machine and that his brain is sending special directions to over one hundred different muscles at the same time. If his brain neurons should make a mistake and cause some of the muscles to contract too much or not enough, the stone would go wide of the mark. It is not strange, therefore, that it takes years of practice before a baseball pitcher can control his muscles so accurately that he can make the ball go where he wants it to go, or strange that a girl must

practice a long time before she can so direct the many muscles of her arms and fingers as to play skillfully upon the piano. During all this time it is not so much the muscles as the army of brain neurons that is being taught, little by little, how to send such orders as to produce the desired results. "Practice makes perfect."

Control of the Neurons. — The power of the commander in chief (cerebrum) to control the neurons is really very wonderful. It can cause a single muscle to contract, or it can cause many muscles to act together. The brain neurons direct many of the voluntary muscles without any attention on our part; we can, however, take charge of this direction by simply giving it our attention. For instance, a man's head is held erect by keeping certain of the neck muscles contracted, but he is not usually conscious of the fact that his brain is giving orders to the neck muscles. If he gets sleepy, his head begins to drop over, since the part of the brain that controls these muscles is beginning to take a rest; and there may be a real struggle between his will to keep the muscles working and the demand for rest made by the neurons that control them.

Training Neurons to Automatic Action. — There is a limit to the number of things to which the higher neurons of the brain can give attention at any one time. If the commanding general has to attend closely to performing a complicated muscle action, he cannot do much thinking. Whenever any action which is controlled by the brain can be made *automatic,* i.e. can be done well without the conscious action of the higher neurons, then these higher ones have time to do other things. Think how a baby must at first concentrate his attention on taking each step.

Afterwards, however, he walks without any conscious effort and is able to ask a constant stream of questions as he runs along beside you, never thinking of how his feet and legs must move. These actions are still controlled by the brain, for if he wishes to stop and look at something, he can stop; but it is no longer necessary for the brain to direct each motion; one passes into another without conscious effort. If a man has what is called a "well-trained mind," the actions of his neurons are to a very large extent automatic.

QUESTIONS

1. Why must the body have a general to command it?
2. Describe a neuron and its work; a nerve fiber.
3. Have you ever seen the brains of a calf or a sheep? If so, describe them.
4. If a person is paralyzed in his right arm, is the trouble in the right or left side of the brain?
5. How is the cerebrum relieved from the work of attending to the petty details of bodily action? Why is this an advantage?
6. If an animal were deprived of his cerebrum, what power would he lose and what powers would he retain?
7. Can you think of any muscles in the body that a baseball pitcher does not use when he delivers the ball? What part of the brain causes the muscles which he uses to act in harmony?
8. Why will an injury to the medulla cause death more quickly than an injury to any other part of the brain?
9. How does the brain get its knowledge of what is going on in the toes and fingers?
10. Are neurons located in the cortex or in the inner part of the brain? Where are they located in the spinal cord?
11. What would be the effect if a man's spinal cord were injured near the neck? If it were injured near the waist line?
12. What organs are likely to be disarranged by a "blow on the solar plexus"? Why?

CHAPTER II

INVOLUNTARY AND REFLEX ACTIONS

Voluntary and Involuntary Actions. — In controlling the body, the nervous system acts in two different ways. Some actions are *voluntary;* we are able to make them at will. These come wholly from the cerebrum. Others are *involuntary,* and we cannot make or stop them by any will power; we may even be unconscious of them, as we are of the churning motions by which the stomach mixes the food. For our life processes the involuntary actions are as important, if not more important, than the voluntary actions. These two kinds of action are closely connected, however, for an action that is at first voluntary may later come to be carried on without special attention on our part and thus become partly involuntary. We will first consider some of the truly involuntary and unconscious actions.

Involuntary Actions

Control of the Heart Beat. — In the case of certain animals the heart will continue to beat when entirely removed from the body. If one knows how, one can keep a turtle's heart beating for days after it has been removed from the body. This shows that the heart (the same is true of our own hearts) can beat independently of any orders from the brain. Its action may be

hastened or checked by the brain, however. We cannot intentionally make the heart beat faster or slower, but nevertheless the brain, without our knowledge, is constantly doing this.

The orders that the brain sends out to the heart come partly from the medulla and partly from the sympathetic system. One pair of nerves passes from the medulla to the heart, and over them messages are constantly being sent; another pair of nerves arises in the sympathetic system, and these nerves carry another kind of message. A boy starts to run; he needs an extra amount of blood circulating over his body. Immediately both sets of nerves send messages to the heart, causing it to beat more rapidly and the blood to flow faster. After the boy has stopped running, another set of orders go to the heart which cause it to resume gradually its ordinary rate.

Control of the Blood Vessels. — We have learned that the amount of blood sent to each part of the body is nicely controlled by changes in the size of the small blood vessels, caused by muscle fibers that pass around them. The action of these muscles is wholly involuntary, but they are acting under orders, some of which come from the medulla and some from the spinal cord through the sympathetic nerves.

That part of the body which is most actively at work needs the largest increase in blood supply, since the blood brings nourishment. Sometimes we have to choose as to the part of the body that shall have all the blood it asks for. The football captain, for instance, if he is going to play a difficult position on his team, one that requires much running, tackling, etc., cannot at the same

time think as quickly and as clearly as he could if he were simply coaching the game. That is not because he gets confused, but for the simple reason that he is using so much blood in his muscles that there is not enough left for the best brain work. Both the muscles and the brain cannot be receiving a largely increased supply of blood at the same time.

Control of Breathing. — Our breathing is largely involuntary, since it goes on all the time whether we are thinking of it or not, but it will not go on a single second if the nerves that pass from the brain to the breathing muscles are cut. The orders to breathe come from a place in the medulla which is called the *respiratory center*. We can slightly modify the orders by our will power, but just as soon as we cease to pay attention to them, they will go in their usual way.

Control of the Digestive Functions. — The churning motions of the stomach, the motions of the intestines to force the food along, are really caused by commands from the nervous system. So, too, the secretions of the various glands, the salivary, the gastric, the pancreatic, and indeed all others, are brought about by messages sent to them through the nerves that connect them with the central controlling organ. Much of this kind of work in the digestive process is brought about through the sympathetic system.

Reflex Actions

Natural Reflexes. — There is another kind of half involuntary action called **reflex action**. When a baby is first born, it can do certain things, such as winking and

sucking its thumb, without learning how. We call these actions **natural reflexes.** The baby is born with plenty of neurons which have nerve fibers leading to skin, to muscles, and to other parts of his body, but he can make little use of them. Long before he can move a single muscle by his will power he is making a great many

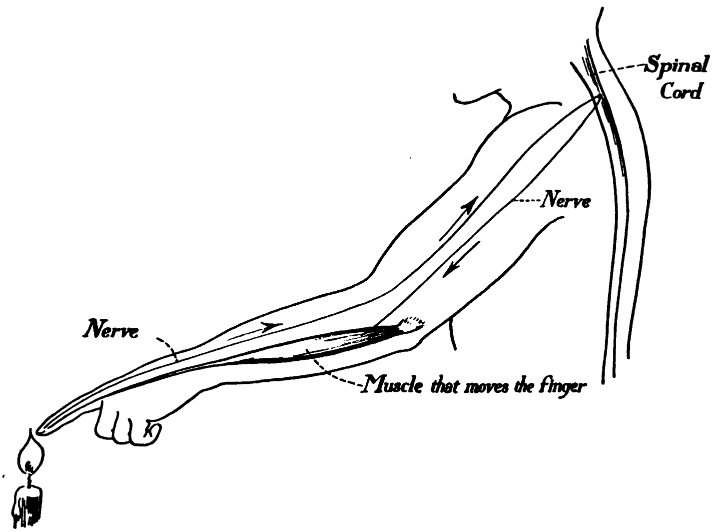


FIG. 86. — Diagram showing (by arrows) the track of a nervous impulse that produces reflex action.

complicated motions. In his skin there are pain spots, touch spots, cold spots, and heat spots. Few things can happen to his skin without arousing one or more of these spots, which are all closely connected with sensory nerves. If the baby lays his finger on a pin point, some sensory nerve sends a report of it to the neurons in the spinal cord. These pass the report on to other neurons

to which are attached motor fibers having control of those muscles of the arm which move the finger, thus causing them to pull the finger away from the pin. Figure 86 shows the direction taken by the messages in a reflex action.

The finger can be pulled away in a fraction of a second, and this will happen equally well whether the baby is awake or asleep. If he is asleep, he will probably not feel the pin prick at all; but if he is awake, part of the message will go on to the neurons in the brain, and give the baby a sensation of pain. This he feels, however, some time after the reflex action of the cord has jerked the hand from the pin. (You see he does not pull his finger away because he feels the pain; it is pulled away before there is any pain.) Probably the baby begins to cry, his experience with pin pricks not being sufficient to tell him whether this one is serious or not; but if the same thing happened to his big brother, the pain would hardly be noticed, for his big brother knows that pin pricks are not worth attending to after the pin is removed.

These natural reflexes, or **instincts**, are of the utmost importance in regulating the life of a baby before he has learned to do anything for himself, and, in fact, throughout life are essential to one's health, safety, and comfort. If a grown man gave all of his attention to the protection of his body from injury, it would not be done as effectively as it is done by the unthinking reflexes.

How Reflex Action Starts. — One peculiarity of reflex actions is that they never start themselves. The neurons of the spinal cord do not pull the finger away from contact with a lighted candle until the sensory nerve fibers have

carried a report to the cord. On receiving that report the neurons act quickly; but these reflex actions are always, as in this case, started by some outside stimulus, and never originate within the neurons. The spinal cord is a great center of reflexes; the medulla is also largely a reflex organ. Much of the work of the cerebellum is also done by reflex action and there are reflex centers in the cerebrum. Reflexes are always purposeful, but since they do not depend upon our wills we do not reason out the purpose for each one. Yet they all have a meaning and they never take place unless there is some need for them.

Training the Reflexes. — While a baby can perform certain reflex actions as well as any one else can, yet these very reflexes may be made more effective by experience. If the baby saw something coming toward one of his eyes, he would wink instinctively, regardless of the size or character of the object. The grown man would be likely to wink, if a small particle were seen approaching the eye; to turn his head, if a flying insect were coming; to put his hands in front of his face, if the approaching object were a baseball. All these different motions would be as truly reflex actions as the baby's, but they are "educated reflexes," based upon much experience with the outside world.

Value of Acquired Reflexes. — There is another form of reflex actions called **acquired reflexes**. They are not born in us; we have to learn how to do them. The baby is born with such natural reflexes as the ability to wink or to suck, but not with the ability to walk. At first he has to make a great many experiments with his

voluntary muscles. Later, when some of the reflexes are trained to the new task, he can take a few steps to reach his mother's arms. His big brother has a similar experience when he learns to skate or to swim, and his sister when she learns to sew or to play on the piano. Reflexes are acquired by doing a thing over and over, until finally the different motions are readily made without our giving attention to them.

The more reflexes we can acquire, the more time the mind (the general in command) has for work which other parts of the brain cannot do. Therefore it is obvious that to train the cerebellum to perform complicated reflexes badly is a great waste of energy on the part of both cerebrum and cerebellum. For instance, the cerebellum can in time acquire great facility in making the complicated combinations of movements necessary in playing the organ; but if one learns to make the movements heedlessly, sometimes doing them right, more often wrong, he will never make a good organist. So while our voluntary actions are gradually becoming reflex actions, we ought to insist on doing them perfectly, for in this way only will our reflexes become well-trained servants. When the organist can play correctly without paying attention to his fingers, or to his feet, he is free to think about the feelings and thought suggested by the music and to try to interpret them for those who are listening.

Reflex and Voluntary Actions. — The essential difference between reflex and voluntary actions may be made more clear by giving very briefly the result of experiments that have been made with normal frogs and with

frogs whose brains have been removed, called for convenience "reflex frogs." If the hind leg of such a frog were slightly pinched, the experimenter could tell exactly what the reflex frog would do — it would jerk its leg away. The normal frog might jerk its leg away or it might decide to jump out of reach. It might even decide, by act of will, to pay no attention at all. The reflex frog would act upon the outside stimulus, but that stimulus (in this case the pinching of the foot) would be only one of the factors that would enter into the action taken by the normal frog. So it is evident that purely reflex actions are quickly made and are not subject to caprice, but can be determined in advance, provided that they are not hampered or interfered with.

Sensations Connected with Reflexes. — Sensation is not necessary to reflex action. If the message sent to the spinal cord is acted upon without going through to the brain, there will be no sensation, since sensations are felt in the brain only. If you drop a bit of blazing sealing wax on your finger, the sensation of pain *seems* to be in the finger, but there is no pain felt until the message that starts in the finger reaches the brain and is there interpreted as pain. There would be no pain if the nerve that goes from the finger to the brain were so cut that the message could not get through to the brain. In that case you would feel no pain at all, even though the blazing wax went burning into your flesh. When the brain feels pain, it locates the pain at the end of the nerve that brought the message. Sometimes the brain makes a mistake; if the nerve from the finger to the brain were injured at the elbow, the message telling of the injury

would cause pain when it reached the brain, but the brain, recognizing the message as coming from a finger nerve, would locate the pain in the finger where there was really no trouble at all.

It is evident now how reflex action may take place when a person is asleep, since the message has to go only to the spinal cord and from there back to the muscles, without entering the brain. Further proof that reflexes act independently of the brain is given by the fact, already mentioned, that they take place perfectly in animals whose brains have been removed.

Voluntary Actions

Most of our conscious actions we bring about by definite intention. Such actions we call **voluntary actions.** Only a few of these actions are possible to a new-born baby, who lives mostly by instinct. Very soon, however, he begins to learn that he can do some things intentionally, and then week after week and year after year his voluntary actions become more and more important, as he trains his numerous neurons to do his bidding.

The Training of Neurons. — The brain, like the army, becomes more efficient the better it is trained. The training of our neurons started long before we ever heard of them. This will be clear if you will watch a baby as he learns to use his muscles and his senses. Think of what you see him doing. All day long he kicks his legs and moves his arms, at first in a seemingly aimless way; but if you realize that by these awkward motions he is getting his neurons into training, maybe you will not wish him to be less active.

When you were old enough to play games you began a new kind of training, and it was all the more valuable because you delighted in the games and did not know that they were serving any purpose except to give you pleasure. Yet all the time they were developing the neurons that control the muscles and those through which the will and the senses work, teaching those used when we think to think quickly and to make quick and accurate judgments.

More Advanced Training. — By and by you were old enough to go to school, and then began a different form of training the neurons. You had been learning to do things because you wished to do them; you wished to play well the games that you saw other children playing, you wished to learn to do things about the home because you found that it gave your parents pleasure when you did them.

At school it was all different; you were told to do certain kinds of work. There was no game about it, and maybe you saw no pleasure in it either for others or for yourself. The simple fact is that the neurons were ready for a different kind of training; the new things given you to do were really no harder than what you had to do as a baby. It is no harder to learn to read than it was, when you were a baby, to learn the meaning of countless messages that were being sent to the brain from your eyes.

Neurons not Trained by Spurts. — A listless pupil always imagines that if the time should come when he wishes to study, or if the subject should be interesting, he could do as good work as any one in his class. That is a

very grave mistake. He knows well enough that he cannot keep his arm in a sling all winter and then pitch baseball fast and accurately when spring comes. Neither the pitching muscles nor the neurons that control them would be fit to work. That is just as true of the neurons that he ought to use when he studies; they, too, have to be exercised constantly. He cannot call upon them for a sudden spurt of work unless he has prepared them for it; he only deceives himself when he imagines that whenever he feels like it he can make up for lost time.

The boy who studies with a will has much more time to give to his other interests than the boy who is always behind with his lessons, because he *thinks about* doing them instead of about getting them done. Remember that the habit of "dawdling" over work will follow you and that you will take into the high school with you the very neurons that you train or fail to train in your grammar school work. Even then it will not be too late to teach them, but you will have to work much harder to get the same result, for you have already trained them in one direction, and thus have formed for them what are called "habits."

Good and Bad Habits. — "Bad habits" are always a hindrance to us, while "good habits" are of the greatest help. Much of our education is designed to give us good habits in speaking, in hearing correctly, in telling a story truthfully, in thinking, in walking, in doing the many actions required by our daily lives. Habits are formed by repetition. Could you write a sentence the first time you tried? Do you remember how hard it was to hold your fingers right, how the pen would not stay where you

wanted it? You kept on trying to write over and over again until the time came when you did not have to think of your fingers or of the letters they were to make; you just *willed* (the work of the cerebrum) to write a certain word and left the rest to the faithful action of the group of neurons that you had trained to direct the muscles used in the writing. Well-trained neurons are of the greatest help to the thinking part of the brain, relieving it of much routine work and giving it time to learn things that we want to know.

Neurons Deserve Good Training. — One of the worst things about a *bad* habit is that it might just as well have been a *good* or useful habit; the neurons that have been allowed to do their work badly could just as well have been trained to do it properly. It is well worth our while to take the trouble to teach these neuron soldiers of ours to work properly, for they are faithful and untiring, and once taught they will continue for a lifetime to act as we have trained them.

Habits may be described as acquired reflex actions, and like all such reflexes, when once acquired, they may be improved. At first one finds it difficult to do any little act, like rising to one's feet when an older person enters the room; by and by it becomes easier and involuntary. One never forgets then, but rises without thinking, and with more real consideration, until finally he would feel uncomfortable if he failed in this act of courtesy. We have made a distinct gain whenever we train a set of neurons to do automatically something that before had to be done by the expenditure of conscious effort.

QUESTIONS

1. Explain the difference between voluntary and involuntary action. Which controls the flow of saliva when we taste food? The flushing of the face when one is embarrassed? The motions of an artist in painting a picture?

2. When a boy starts to run, what changes take place in his circulation and what controls these changes?

3. Explain why, when a barefooted boy steps on a sharp stone, he jumps before he actually feels the pain.

4. Can you mention any natural reflexes (instincts) which a newly-hatched chicken possesses?

5. What natural reflex movement occurs when a bit of food gets into the windpipe? Name as many more natural reflex movements as you can think of.

6. What happens if you tickle the foot of a sleeping person? Was he conscious of the tickling? Explain your answer.

7. Mention several reflex actions that you have acquired.

8. Why is one unable to ride a bicycle, row a boat, or swim perfectly, the first time he tries?

9. What effect would it have on your progress at school, if you had to think about each movement every time you walked about or changed your position, or did any writing? Why is it better to perform ordinary actions by reflex action rather than by conscious attention?

10. Has the playing of games any real value to a boy or girl? Explain. Can you see any reason why boys and girls do not like the same kinds of plays?

11. What is gained by training our neurons to reflex action early in life?

12. What are habits? How are habits formed? Is it harder to form good habits than bad ones?

13. How do the bones and muscles of the shoulders get the habits which make a person round-shouldered? In what way might the same bones and muscles have formed other habits?

14. What is the meaning of the saying, "You can't teach an old dog new tricks"?

CHAPTER III

BETTER GOVERNMENT OF THE BODY

How the Mind Works

The Mind Works through the Cerebrum. — The commander in chief of our army of neurons we call the **mind**; this is the part that thinks, that feels, and that wills. We do not know much about how the mind uses the rest of the nervous system, nor just what the mind is, but we do know that it works through the cerebrum. There are many interesting facts that show this. If a clot of blood forms on the brain, it produces various mental disturbances, sometimes causing the person to lose his mind entirely for a while. These troubles pass away when the clot is absorbed. There have been accidents which have broken away part of the skull so that the brain could be seen. Scientists who have carefully watched the exposed brain have found that when the patient goes to sleep and becomes unconscious, very little blood goes to the brain, but that as soon as he wakes the blood flows there rapidly. If he thinks hard, a very large supply of blood goes to the brain. All this shows that the brain works when we think.

So students have concluded that the mind does different kinds of work in different parts of the brain. This theory has been tested in many ways. Sometimes a certain part of the brain may be injured by a fall or a blow.

This causes some special effect upon the mind. For example, injury to one part of the brain injures or destroys the power of hearing, while injury at another place interferes with vision. By comparing many such cases it has been possible to determine the particular parts of the brain with which hearing and seeing and many other mental actions are connected. Figure 87 will give some idea of the results of these discoveries, for it shows what kind of actions are associated with the different parts of the cerebrum.

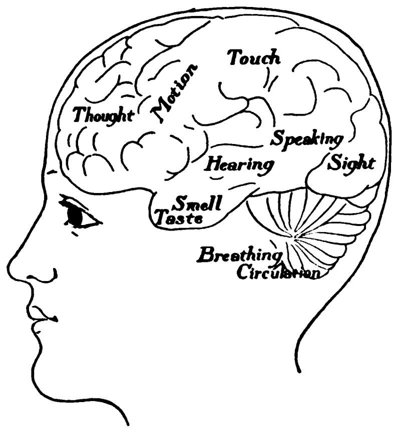


FIG. 87. — THE BRAIN IN POSITION IN THE SKULL.

Showing the location of some of the chief functions of the cerebrum.

Memory. — There does not seem, at first thought, to be any connection between memory and the neurons. You learn a song to-day and perhaps years from now something reminds you of it. You may recall a part of the tune or a line of the words, and with whatever clew you have you begin searching your memory, trying to find the rest of the song. Where is it?

The simplest answer seems to be that it is stored up in some group of neurons. You can find it again if you succeed in calling upon the right group. We may perhaps think of the neurons that are trying to bring back the song as actually sending out one message after another

through all their many branches, in their efforts to locate the ones that have retained the song (remember that there are 9,000,000,000 of them). The situation would be different if you had been in the habit of singing that song frequently. Then there would be no difficulty in getting the message of the proper neurons; the path to them would be well known.

Memory depends also upon the *distinctness of the impression* made upon the neurons. Listless, half-hearted attention to one's lessons, when one's mind is on a ball game perhaps, has much the same result as writing on a sheet of paper with a pen that carries no ink.

Reasoning. — Memory is not confined to men, as animals have a clear memory of certain things. Many a man traveling on an exposed and lonely road prefers to trust his life to his horse's memory of the turns rather than to trust his own. *Reasoning,* however, appears to be almost, if not wholly, beyond the capacity of the neurons of the animal's brain. Many tests have been made with the animals that are nearest to man, comparing their mental powers with the mental powers shown in the lowest types of mankind. A striking difference is noticeable. An intelligent chimpanzee and a low type of savage were once shut up in huts. The only opening in each was fastened by a lock that could be released only by pulling out a pin that was placed perpendicularly in the lock. Both wanted to get out, both worked hard to find out how they could undo that strange kind of fastening, and both succeeded in discovering that by removing the pin the door would open. The lock was then rearranged so that it would work only when the pin was

placed horizontally. Both the savage and the chimpanzee were again shut up in their huts. The savage recognized the pin in its new position and quickly released himself, but the chimpanzee had to start all over again with his efforts to undo the lock, fumbling and trying as though he had never experienced such a lock before.

The chimpanzee can remember as clearly as we do the people whom he likes or dislikes, but he shows little if any evidence that he is able to reason about his feelings or to decide to control them.

The Care of the Mind

Brain Work and Fatigue. — It is known that neurons grow stronger with use. There is no reason why people should fear the result of hard brain work, if only they would use as much common sense about it as they would use in the care and training of a hunting dog or a work-horse or any other animal that had hard work to do for them. We do not need to search for brain foods or to take alarm lest each slight headache means that the brain is being overtaxed.

When a man is carrying a heavy package, he "changes hands" occasionally, knowing that in this way he can carry the load farther and with less fatigue. A similar advantage is gained by alternating exercise and brain work; they are different methods of using the neurons, and to a large extent different groups of neurons are employed in the two kinds of work. So the groups that are used for brain work have a chance to rest while those which direct the work of the muscles are active. But suppose that the man with the package were to carry it

in his right hand as long as he could possibly hold it, and then, after his right arm was absolutely tired out, were to change the package over to the left hand. What would happen? He would find (and this can be readily tested by any pupil) that his left hand and arm instead of being fresh and strong were tired at the start, because of the fatigue poisons that had been produced by the severe overstrain of the other arm.

It has been proved that the same thing happens with the groups of neurons. "Fatigue" experiments are constantly being made in laboratories to demonstrate the relation between brain "fag" and muscle "fag." They show that a man can do a certain amount of work with a single set of muscles the first thing in the morning, and that after an hour of study he can again do just about the same amount of muscle work. But let him study hard for five hours on a stretch and then test the ability of his muscles to pull a weight. Even though during these five hours neither the muscles nor the neurons that control the muscles have been working, yet he finds that they will not work well no matter how hard he tries. The fact is, they share in the overfatigue of the other neurons of the cerebrum. The only way to make them fit for work again is to sleep, or to take time for a complete rest.

Concentration. — This is a hard sounding word, and suggests a disagreeable amount of effort; but just watch a boy enthusiast at a football game. He is enjoying himself every moment of the time; his entire interest is fixed on the play; yet he would probably think you were making fun of him if you were to tell him that he was an excellent example of **concentration**.

The secret of concentration is interest. When we are thoroughly interested in a subject, it is only natural to turn our whole attention to it; and the result is that we learn more about it and enjoy it more thoroughly than we could in any other way. Take a hard case: a boy has some difficult problems in percentage to do; he does not like arithmetic very well, and percentage seems to him the dullest of all its topics. How can he concentrate his mind on the problems? This much is evident: the shorter time he takes to do them the less they will annoy him; the sooner he completes the whole topic of percentage, the sooner he finishes his book in arithmetic, the sooner he will be free from what is to him drudgery. So his desire to solve those problems and be free to do something he likes to do ought to enable him by his will power to fix his entire attention on them; then they can be completed in one quarter the time that they might otherwise take.

The ability to think of one thing at a time is very largely a habit and one of the habits that must be acquired by everybody who wants to do good work. Wandering attention does not make for success in any line of work, nor is there enjoyment in work done in that way. Unfortunately the *habit of letting the mind wander* is easily acquired by those who do not take the trouble to acquire the habit of concentration. Which of these two habits are you forming?

Recreation. — The mind needs recreation, especially recreation taken with the sort of enthusiastic interest that the boy in our illustration gave to the football game. If he had spent the afternoon at that game with no interest

either in the game itself or in the players, just taking it in as a means of "killing time," he would get little or no recreation. Everybody needs to discover some form of recreation for which he has time and opportunity. It should be something that he *likes to do*. The mention of a few possibilities for the boy and the girl will suggest how many others there are to be considered — stamp collecting, training pets, making pieces of furniture, skating, swimming, climbing, gardening, knitting, embroidery, fine cooking, fine sewing, house decorating, candy making.

The form of recreation chosen matters little, provided that it is something we delight in doing and provided, further, that we do it with energy and enthusiasm. To be indolent or negative or half-hearted about our recreation changes it at once from *good play* into *poor work*. You have seen boys who go onto the athletic field or into a gymnasium and stand around, first on one foot and then on the other, watching those who are taking part in the games. They may take part for a few minutes in something that looks easy, but they are usually just waiting for something else to happen. They are not getting recreation, for they are not doing anything positively and with satisfaction.

How to Rest. — *Partial rest* comes from change of work (if the change is made before one is too weary), and especially from work interspersed with recreation. *Complete rest* comes from sleep and absolute inactivity. The student does not progress according to the amount of *time* that he spends over his books, but according to the amount of *work* he does upon them. When his mind is

alert and attentive, he can accomplish more in half an hour than he can in an hour of listless work when his brain is tired. A half hour given to complete rest in the middle of the day may enable him to master his lessons more quickly and more thoroughly than if he had studied that half hour.

When Things Go Wrong. — Everybody has days when nothing seems interesting, neither work nor play, —when everything seems to go wrong. This usually means that one has eaten too much or slept too little. When some mistake of that sort has robbed us, for the time being, of the interest and joy we ought to have in work, the only thing to do is to "borrow" some from the future; that is the only kind of borrowing that makes one rich. So borrow a happy face; meet every difficulty with a laugh, no matter if you do feel more like crying; undertake your tasks with courage, and before you know it things will begin to go right again.

Sleep the Restorer of Neurons. — An exhausted neuron has its own way of showing its fatigue, but it takes a microscope to see the change. When greatly fatigued, the nucleus of the neuron shrinks and begins to look crumpled and ragged. After a good night's sleep it becomes firm and clear again.

When an athlete is preparing for a race or when a scholar is preparing for an examination, he needs to be ready when the time comes to do his very best work. The athlete goes to bed early; the scholar frequently sits up late studying. Which takes the more sensible course? Every trainer knows that the man who has not slept the night before has no chance at all in a rowing match, even

with an inferior opponent; the issue between them is soon decided beyond all doubt. But this is not so readily appreciated by the student.

Sometimes boys and girls take pride in studying far into the night. They find much work that could be reviewed with profit, and they may be convinced that on this one occasion they need to study until midnight. That feeling may be well founded. They may need to know many things that they have neglected to learn, but it is too late to learn them. To try to prepare for a test in that way is a most absurd blunder, because what one tries to learn under such conditions makes very little impression on tired neurons. Many facts may be crammed into one's head by such midnight study; but when morning comes, they are usually no longer there. The result of our night's work has been only a tired brain, which unfits us to acquit ourselves as well as we otherwise might.

Habits of Sleep. — In ways of which we are totally unconscious the body adapts itself to regular hours for stated duties, and works with much greater ease and accuracy when we are systematic. Regular habits of sleep are as desirable as regular habits of eating. Children are sometimes glad when they "outgrow" a regular hour for bedtime; but the fact is that grown men and women would feel better and work more successfully if they would go to bed at the same hour every night. Many cases of habitual wakefulness might have been prevented by the formation of such a habit. Young people are seldom troubled about getting to sleep. Five minutes after one gets into bed one should be asleep, and that five minutes

ought to be kept free from thoughts about work or worries. It is very easy to form the habit of thinking, the last thing every night, of something very pleasant; that helps to insure sound sleep and a happy waking.

Few persons sleep too much, many sleep too little. Grown people need to sleep from seven to nine hours; children from ten to twelve; babies from sixteen to twenty. So much depends upon the individual and his work that no fixed rule can be made for all. If one forms the habit of going to sleep quickly and of getting up instantly on waking, there is little danger that he will take more sleep than he requires. There is much wisdom in the quaint old saying, "When you wake, jump out of bed as though the bed were on fire."

A Sound Mind in a Sound Body.—Mind and body are so closely related that it is useless to try to train the mind to do its best if one neglects to keep the body vigorous. To be sure, the mind can rise above many physical ailments, forgetting and ignoring them as it works. That it should be made to do; but we are deluding ourselves if we imagine that our minds work as well under those circumstances as when we are in good physical condition. Those who enjoy books and study should be especially careful to keep themselves in good health. Recreation, exercise, wholesome food, fresh air, and sunshine must be sought by the student who is eager to excel in any kind of mental work. Rightly used they will help him toward his goal. Otherwise he resembles the man in the fable who worked every day on a stone wall, and who every night, when he was asleep, got up and pulled down what he had done the day before. We see people with sound

bodies but with minds dull and inactive through lack of mental exercise; they resemble trees that look well but never bear fruit.

Nervousness. — We frequently hear it said that a child or a grown person is very **nervous** or is having a "nervous breakdown." The pioneers in our country never seemed to have such troubles, although they probably worked harder than the busiest men of to-day, showing that nervous troubles are not due to hard work. The pioneers did, however, work under less strain; to-day the complicated conditions of business competition bring much anxiety and worry, and that will cause more trouble than hard work ever does. Neglect of the body is to-day a more common cause of "nervousness" than overwork of the mind. Nervous excitement may occasionally arise from some diseased condition of the body. The remedy is to discover the cause and help the body to right itself; when that is done, the nervousness will disappear.

The most prevalent form of nervousness is not due to physical conditions or to business strain, for it finds its victims chiefly among women and children. Physicians are agreed that this is the most serious form of the disorder because, not being physical, it cannot be reached by physical remedies. The sovereign remedy is in the training of the will. Children and young people are subject to those forms of nervous excitement that come from lack of self-restraint. If denied something that they desire, or required to do something that they dislike, they become "nervous" or hysterical, and their friends may say that they are too "delicate" to be crossed in any-

thing. A physician would state the situation in another way; he would say, "That child is still more animal than human; the trouble is not with his nerves but with his will."

Over and over again it has been proved, by physicians and by parents, that most nervousness is only a form of selfishness; the nervous system is thrown into disorder because the individual is determined to get his own way, regardless of the rights and wishes of others. Even a very young child can understand this. The cure is as much in his own hands as in the hands of his elders. Every human being ought to be master of his own will. This mastery is most easily acquired when one is young; but if not gained then, the earlier we get at the task, the sooner we shall conquer and the happier we shall be. When the will is strengthened, nervousness usually disappears.

A good beginning is to make oneself do, every single day, some useful or kind act that one does not wish to do, — such as giving up a favorite chair or book, smiling when one feels like frowning, saying a kind word when one wishes to be disagreeable. If some such thing is done day by day with this deliberate intention, one is sure to gain control of the will. This does not imply that a child's will should "be broken," in the general meaning of that old phrase; just the opposite. The difficulty is not that he has too much will, but that it is so stiff and unyielding that *he himself cannot use it.* He gains will power as he learns to use rightly what he already has, for the will grows with proper use just as much as muscles do.

QUESTIONS

1. What part of the brain do we use when we listen? When we look at a picture? When we think?

2. Relate some instances in your experience which show that animals have memory. Have you ever heard of instances where animals seem to reason? Do you believe it was a real reasoning?

3. How do we "exercise" our brains? Can our brains as well as our muscles be made strong by exercise? What would happen to the brightest mind in the world if it were not exercised?

4. Could you play a good game of baseball or basket ball immediately after a hard examination? Could you do as well in an examination immediately after a hard game? Explain your answer.

5. When do you find it easier to study — in the morning or in the evening? Why?

6. What is the object of having "recesses" at school? Would it not be better to do all your work at once so as to have uninterrupted time for play afterward? What is the best way to use your time at recess? Why does every one need some sort of recreation?

7. Name some subjects on which you find it easy to concentrate attention; some on which you find it difficult. If your mind is apt to "wander," what do you think is the best way to set about curing this habit?

8. Why is it important that a schoolroom be quiet?

9. What is the only remedy for a thoroughly tired brain or set of muscles?

10. What is the most sensible way of preparing for an examination?

11. How much sleep does one ordinarily require? Do you see any harm in attending an exciting moving picture play shortly before going to bed?

12. Which is the most efficient and successful person — one who has little or no will power, one who has a strong will which has never been controlled, or one who is both strong willed and self-controlled?

13. Mention some ways of strengthening the will power.

CHAPTER IV

INTERFERENCE WITH THE CONTROL OF THE BODY

Stimulants and Narcotics. — There are certain substances that interfere most seriously with the health and vigor of various parts of the body; they are sometimes called **stimulants** and sometimes **narcotics.** Let us see in which class they really belong.

Stimulants increase the activity of the body or of some part of it. For example, hot water stimulates heart action; the chewing of rubber stimulates the secretion of saliva; strychnine, when used in minute quantities, stimulates the heartbeat, though it is only a temporary stimulant, in the end reducing the activity of the heart.

Narcotics have just the opposite effect; they soothe and dull the action of the body and have a tendency to put people to sleep. By decreasing the activities of the brain, they first make a person dull and stupid; if taken in large quantities, they make him totally unconscious. Although the effects of narcotics and stimulants are so different, they are often confused, particularly in the case of certain drugs which produce both effects. When used in small quantities, such drugs have the effect of stimulants; but when used in large quantities, they have a marked narcotic effect. Before the days of careful laboratory tests some drugs were classed as stimulants (because

people *felt stimulated* after taking them) which are now clearly demonstrated to be narcotics. The person who takes them is simply deceived; he thinks they help him to work better, but the tests show that he is actually doing less.

Opium

Opium quickly dulls the senses; if taken in sufficient quantity, it makes a person totally unconscious. It is one of the most dangerous of the narcotics because it has a tendency to produce a terrible *craving for opium.* A person may begin by taking a small amount, often merely to relieve serious headache or neuralgia. The drug not only soothes the pain, but produces a restful feeling which he enjoys. Then, especially if it was *prescribed by his doctor*, he may acquire the habit of using the same remedy whenever he has a real or an imagined pain, for the sake of the pleasurable effects. Soon, because the small doses with which he began do not produce the desired effect, he takes a larger amount; and before he suspects the fact he has become a "drug fiend," the slave of opium, no longer using it as a medicine but because he is miserable without it. Opium weakens the will, destroys the ability to think clearly, and undermines the health, until even the drug itself ceases to give relief or satisfaction.

Physicians are becoming less and less willing to prescribe opium in any form, because so many people continue its use. To use it, except under the advice of a physician, is exceedingly dangerous. *Paregoric, laudanum, morphine,* and *soothing sirups* are forms of opium and should all be avoided.

Tobacco

Tobacco, a mild narcotic, and one that is widely used, is by no means to be classed with opium and other dangerous narcotics just enumerated. It contains nevertheless a poison called *nicotine* which is dangerous when taken in considerable quantity. Its effect, whether in small or in large quantities, is much more marked in young people than in adults. For young people tobacco is always found to be harmful. Adults may use it moderately without showing ill effects from it, but when freely used, it is undeniably injurious. Following are some of the reasons why one should refrain from the use of tobacco:

1. The use of tobacco tends to *check the growth and development* of the body. Careful records made of college students show that those who are addicted to the use of tobacco are, on the average, less developed, both as to muscles and chest capacity, than those who let it alone. What boy wants to handicap his physical development at the very start?

2. The use of tobacco temporarily *reduces one's muscular power,* and may do so permanently.

3. The use of tobacco often causes *heart trouble.* A person with a "cigarette heart" cannot take out a life insurance policy.

4. The use of tobacco is likely to lead boys into injurious company, inviting them to idleness and to other bad habits.

5. Tobacco makes boys dull at their studies. The boys in your school who use cigarettes will almost surely be among the dull scholars.

6. Statistics are all against the use of tobacco by young people; it has been proved in many different ways that the boy who does not smoke has an advantage over the one who smokes. Of that there can be no doubt at all except in the minds of those who do not know the facts. Some of these facts, proved by experiment and observation, are interesting.

Only ten per cent of the cigarette smokers among pupils in city schools are able to keep up with their grade.

Only one-half as many smokers as non-smokers are successful in tryouts for college athletic teams.

Seventy-seven per cent of those who were dropped from a certain college for inability to keep up with their classes were smokers.

For fifty years not a single student who used tobacco stood at the head of his class in Harvard University.

Cigarettes undoubtedly cause more injury than all other forms of tobacco. There are two reasons for this. (1) They are so cheap and so small that one is apt to smoke too many of them. (2) The smoke from them is almost always "inhaled" into the lungs instead of being taken into the mouth only (as is the custom generally with cigar smokers); smoke in the lungs is far more disastrous than in the mouth, since the lungs are especially adapted for absorbing gases.

Cigarettes have sent many people to insane asylums, and have made stunted and nervous men of many boys who would otherwise have been well grown, strong, and vigorous. The cigarette habit is a hopeless handicap in a boy's search for success either in scholarship, on the athletic field, or in his after business life. The boy who

does not acquire this habit is practically sure to outdistance the cigarette smoker. Cigarettes lead more boys to the criminal court than all other causes together. Out of 300 boys that came before one such court 295 were cigarette smokers. At the present time many American boys fall victims each year to the devastating cigarette habit.

Alcohol

A Narcotic. — Alcohol is another drug that does great injury. In the form of *beer*, *wine*, or the stronger liquors it is not infrequently, though wrongly, called a *stimulant*. *Alcohol is undoubtedly a narcotic,* and acts as a brain poison. Its first action is to dull the powers of self-restraint in the brain, thus causing a person to say and do things that give a false impression of strength. As its action increases, the dulling effect becomes more manifest; the person becomes more and more stupid, less and less able to control his muscles, and finally when he becomes completely under its influence he is utterly unable to think or to work. It used to be thought that alcohol increased one's power to do hard work, but the careful investigations of recent years have proved that this is a mistaken notion; all who have to work hard should avoid its use.

A Foe to Success. — There is no one thing that prevents so many men from making a success in life as does the use of alcohol. If some new disease were to appear that destroyed hundreds of thousands of lives every year and left its victims so demoralized that they filled the records of police courts and insane asylums and charity

organizations, how alarmed we should be, and how loudly we should call upon physicians and scientists to discover some way to stop the ravages of this new disease, and to prevent its spread. So, when our government experts tell us that every eight minutes one person dies in our country from the use of alcohol, how can we overlook the enormity of the danger?

The evidence is all against the use of alcohol. There is no denying that the boy who begins to use alcoholic drinks becomes dull at his studies, careless in his habits, loses his ambitions, associates with bad companions, and in general becomes one from whom not much that is good can be expected. Any young person, boy or girl, who starts to make a place in the world needs to start with all possible advantages; the most valuable advantages are **good habits**. The worst possible handicap to a boy's success in life is to have it said of him that "*he drinks.*"

Moderate Drinking. — Alcoholic drinks, even when used in small quantities, produce decided effects upon the body, but those effects are not always apparent. Little by little the injury is done. Some people use wines or beers in small amounts for years, all the time denying that they are injured by them. They are doubtless honest in their belief, but they are mistaken; for it has been demonstrated beyond all doubt that the habitual use of alcoholic drinks, *even in small quantities*, has distinctly injurious physical effects. Experimenters have been surprised to find that they could measure the decrease in muscular power that resulted from taking only two drinks.

The strongest temptation comes to the boy before he understands what the results of drinking are likely to be. Of drunkards, over one-half acquire the habit before they are twenty years of age. A large majority of them begin to drink because they desire to be sociable; they commonly begin with beer, which friends tell them is harmless, and so they consent to "join in a social glass." This is the beginning of the road, long or short, that leads its unsuspecting victim to drunkenness.

Some Recorded Tests. — *The effect of alcohol on muscle power* was shown in a German walking match. Of the men who started in the match 59 were users of alcohol and 24 were abstainers; 60 per cent of the prizes were captured by the 24 who did not use alcohol.

Its effect on endurance is illustrated by a shooting test in the Swedish army. On some days the soldiers were allowed to have a little alcohol and on other days none. On the alcohol days they could fire only 278 shots before they became exhausted, while on the non-alcohol days they could fire 360 shots. Upon their quickness and accuracy alcohol had an equally unfortunate effect; for on the alcohol days they made only 3 bull's eye shots out of a possible 30, while on the non-alcohol days they made 24 out of a possible 30. In the great European war the English army found that alcohol destroys accuracy in shooting and, indeed, in everything else. In iron works, where the employment is dangerous, the deaths from accidents are a third fewer among those who do not use alcohol at all.

Its effect on the mind is shown by the fact that at least one out of every four persons sent to an insane asylum

became deranged through the use of alcohol. Alcohol acts primarily upon the brain, though its effect is unfortunately not always apparent. Even a small amount of alcohol takes away one's power to concentrate his mind; the result is that he cannot work as fast and that he makes more mistakes.

It lowers the power of resistance, the doctors tell us, so that even the "moderate" drinker has less chance than a non-drinker to recover from any serious disease. The statistics of the insurance companies show that moderate drinking shortens the average life from ten to thirteen years. This lowered resistance is seen not only in the drinker himself but in his children.

Some Recorded Results. — When the great European war caused the nations to consider in real earnest the ways in which the prosperity and vitality of their people were being lowered, when they were desperately anxious to strengthen their weak spots, they decided that they could not risk the continuance of alcohol drinking. In one form or another citizens called on each other to show love of country by giving up the use of intoxicating drinks during the continuance of the war, and the sentiment was so strong in favor of this that country after country made regulations either prohibiting, or greatly restricting, the use of alcoholic beverages. What happened? *In Russia*, the deposits in the savings banks for the poorer classes increased from $350,000 in December, 1913 to $15,000,000 in December, 1914. One of the insurance companies in Russia estimated that crime diminished 62 per cent during the first year of prohibition.

In England, the prohibition of treating in the city of

London caused a reduction in the number of cases of drunkenness of between 30 and 40 per cent. Total abstinence was forcefully urged in England during the second year of the war on the ground that the $800,000,000 annually spent for drink was only a small part of what it actually cost the country. It is stated that of the 668,000 working hours lost every week in the ship building trade alone, 80 per cent of this loss was due to drink.

QUESTIONS

1. What is the general effect of stimulants on the body? Of narcotics? Is alcohol a stimulant or a narcotic?
2. What effect has opium on the body? On the mind and character? How is the habit frequently acquired? Explain why it is difficult to throw off the habit.
3. What poison is found in tobacco? What harmful effects has tobacco on the system of a growing boy?
4. What is the most injurious form of tobacco? Why?
5. If a boy were to begin smoking at the age of twelve, spending ten cents each day for cigarettes, how much money would he have spent in this way by the time he was twenty-one?
6. Are there any laws in your state regarding the purchase or use of tobacco by boys?
7. How does even a moderate drinker lessen his chances of recovery, in case he is attacked by a serious illness?
8. What was done by the nations engaged in the European War of 1914 towards prohibiting the use of alcohol? What were the results?
9. If the use of liquor were prohibited in this country for the next fifty years, what effect do you think it would have on our jails, poorhouses, insane asylums, institutions for the feeble-minded?
10. Why do railroad companies refuse to employ men who drink?

CHAPTER V

THE PART PLAYED BY THE SPECIAL SENSES

Sight

THE operator shut up at the "central" station of a telephone system knows much that is going on all over the city by the messages that keep coming in. "Central," too, can send messages all over the city. The "central station" of the body is in the brain, shut up in its bony box, the skull. From this station, as we have seen, nerves extend to every part of the body; there are the *motor nerves* that carry messages or orders to the different parts of the body; and there are the *sensory nerves* which carry messages that cause, when they reach the brain, what are called *sensations*, giving us news of the outer world as well as of the different parts of the body.

The sensory nerves end in organs called sense organs. Many of these sense organs are very simple, having only simple functions to perform, like that of receiving touch, heat, and pain stimuli. Of these some are excited by pressure on the skin, which immediately sends an impulse to the neurons in the brain, causing a sensation which we call *touch*. A burning match or a piece of ice may excite other sense organs in the skin, giving us sensations of

heat or *cold* when these impulses reach the brain and are interpreted.

There are other sensory nerves, however, which end in much more elaborate sense organs, such as the eye and ear. The eye is an organ that is excited by light waves, the ear by sound waves; the messages from these organs give us sensations which we call *sight* and *sound*. Other organs — those in the mouth and nose — give us sensations of *taste* and *smell*.

Our various sensations may be arranged in two groups: (1) **General sensations**, like *pain*, *hunger*, and *thirst*, which tell us of the condition of parts of the body. (2) **Special sensations**, sight, hearing, taste, smell, and touch, — our "five senses," — which are caused by impressions from things outside the body. These give us all our knowledge of the outer world.

The Eye

When we speak of the eye, we seldom think of it as a sphere. The front part of the eyeball is the only part that is seen as we look into one's eyes; the rest of it, which is almost a perfect sphere about one inch in diameter, being covered by the lids, or hidden in the deep sockets in the front of the skull. We talk of large eyes and small eyes, yet the dimensions of the eye really do not vary much. There is, however, a great difference in the extent to which the eyelids cover the eyeball. The eye looks large or small according as the eyelids are opened wide or are partly closed. Figure 88 shows the eye as it really is, a ball set into a deep socket in the front of the

skull, with only its front surface exposed. This bony socket is of great service in guarding the eye from injury through blows and falls.

The Protectors of the Eye. — The front of the eye is protected by the eyelids, two folds of skin that hang over

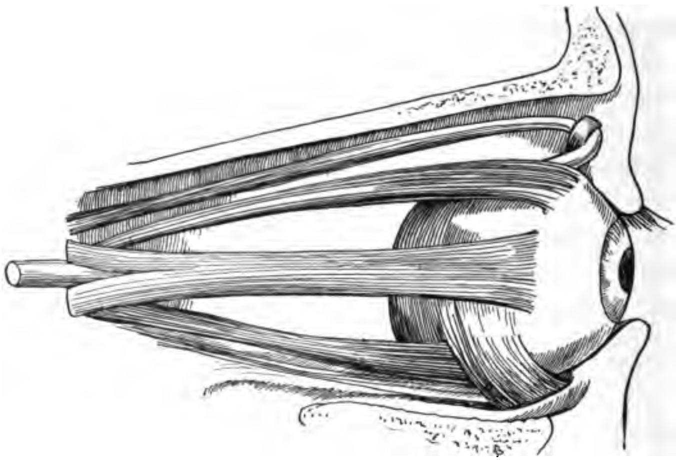


FIG. 88. — THE EYEBALL.
It is represented natural size, and in position in the eye socket, with the chief muscles that move it.

the eye, one from above and the other from below. A portion of the front of the eye is always covered by these lids, and they are constantly being closed and opened. When closed, they protect the eye and keep its delicate surface clean and moist. If the lids did not constantly cleanse the surface, if the tear secretions did not wash the dust away, the eye would become inflamed. So the eyelids keep closing every few seconds, with a movement that we never notice in our own eyes, but which one can

easily observe in the eyes of others. By their long lashes which assist in keeping out the dust, and by their exceedingly quick motions, the lids also serve to guard the eye against accident.

How the Eye Is Kept Clean. — Just above each eye, on the side next the temple, is a small **tear gland** or **lachrymal gland**, which produces a watery liquid that flows down over the surface of the eye and keeps it moist. On the inner edge of the eye, near the nose, there is a tube, called the **tear duct**, which empties into the cavity inside the nose. After the tears have washed the surface of the eye, they pass through the tear duct into the nose, and then to the throat, where they are swallowed. (The expression "she swallowed her tears" has good physiological foundation.) Usually the tear gland produces just liquid enough to wash the eyeball and that amount passes easily down the tear duct. Sometimes under the influence of strong emotion tears are produced faster than the duct can carry them off. Then one "cries." The tears overflow the eyes and run down the cheeks. A similar thing happens when the tear duct is stopped up.

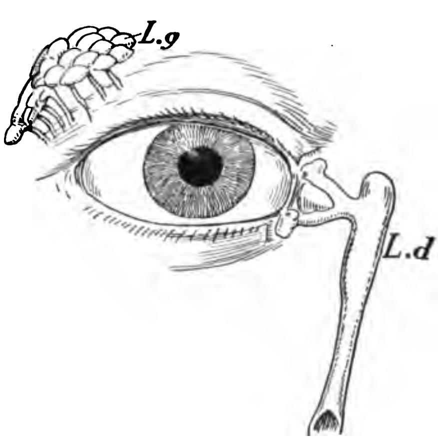


FIG. 89. — THE EYE FROM IN FRONT.
The figure shows the location of the lachrymal gland, *L.g.*, and the lachrymal duct, *L.d.*

Then one becomes conscious of the amount of moisture that is being constantly drained off from the eye.

What Moves the Eyes? — The eyes make an incredible number of movements every hour. Of most of these we are entirely unconscious; they are largely voluntary movements, but are made under the direction of highly trained groups of neurons which require little conscious attention from us. The motions of the eye are controlled by six tiny muscles attached to each eyeball. One is on the top, one on the bottom, one on each side, and two obliquely placed, as is shown in Figure 88. By the contraction of the different muscles the eyeball can be turned in any direction.

The Eye as a Camera. — Nature made a camera long before man ever learned how to do it. A photographic camera has three essential parts: (1) a *dark chamber*, the box of the camera, which is so closed as to admit light only from the opening in front; (2) a *lens* which is placed across the front opening, and which makes an image of the object to be photographed; (3) a *sensitive plate*, located at the back of the camera, upon which the picture is taken. The human eye has its dark chamber and its lens and its sensitive surface at the back; Figure 91 shows the comparison between the eye and the camera.

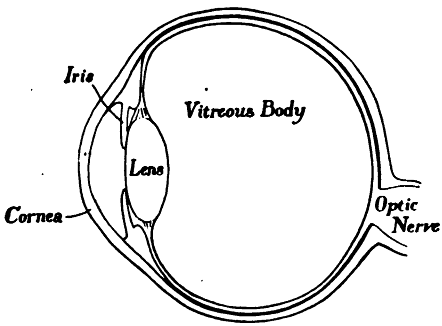


Fig. 90. — Section of the Human Eye.

The eye's *dark chamber* is the eyeball which admits light only from the front. Its **lens** is at the point at which light is admitted. At the back of the rounded, dark chamber is a *sensitive surface* called the **retina.** Between the front of the eye and the retina the eyeball is filled with transparent liquids, through which the light can easily pass.

The **pupil** of the eye is the small opening in the front through which the light passes. You see it as a black spot in the middle of the eye. If you look at the pupils of another person's eyes when he is in a bright light, you will find that they are very small, and that they are much larger in a dim light; for then the opening is enlarged to let in as much light as possible. The pupils of a cat's eyes open wider than ours can, which is one reason why cats see in the dark better than we can.

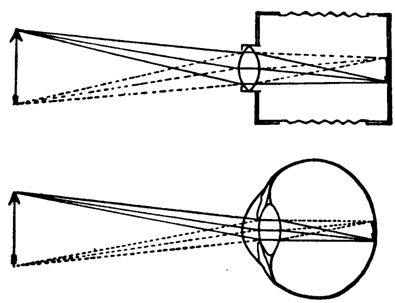


FIG. 91. — TWO CAMERAS.
A diagram showing the similarity in the structure of a photographic camera and the eye.

The **transparent lens** just inside the pupil is so shaped that when rays of light strike it, their direction is changed and they come together (focus) at the back part of the eye. If you could look at the retina, you would find upon it a tiny picture or image of the object at which the eye is looking and from which the light comes. This image is similar to what we see on the ground-glass screen at the back of a photographic camera. The image

changes as rapidly as the eye is turned from one object to another. But you must not think of the brain as looking at the picture on the retina. The process is far more complicated than that.

The retina is full of nerves which, stimulated by the light waves coming from the object looked at, send impulses to the brain. These impulses the brain receives and interprets as the picture. We could not see if the nerves that connect the eye with the brain were severed, because the message would never reach the brain. Nor could we see, with perfect nerves, if the eye were so injured that no image could be formed on the retina.

The photographer has to change the focus of his camera when he turns it from a distant object to take a picture of an object near by. So the lens of the eye has to be changed when we look from a distant object to one close at hand. If we are observing a distant hill, for example, and wish to read a description of it from a book in our hands, the shape of the lens must be changed before the book can be sharply pictured on the retina; when this is done, the image of the hill necessarily becomes somewhat blurred while the image of the book is sharp and clear. These changes in the lens are made very rapidly by a delicate little muscle which works with great accuracy.

Figure 90 shows a cross section of the eye. In that figure, the part labeled "vitreous body" corresponds to the dark chamber. The transparent layer in the very front of the eye is named the cornea, and the membrane or veil which contains all of the color is called the iris. It is the iris that makes the eyes blue or brown. It is a change in the shape of the iris that opens and closes the

pupil, which is the opening in the middle of this iris. The sensitive part of the eye is at the very back of the eyeball, and is called the retina.

Nearsightedness. — If the eyeball and the lens are of exactly the right shape, we can focus our eyes so as to see near-by or distant objects at will. If the eyeball is a little too long, or if the lens is a little too bulging, we can focus near-by objects on the retina clearly and sharply, but distant objects will be somewhat blurred. We say that a person who has this difficulty is **nearsighted**; in order to see distant objects clearly, he must wear glasses so prepared as just to correct the defect in his eyes.

Some people are born nearsighted, but this form of defective vision is more often caused by improper habits of study. Children frequently lean over a desk or a table when they read, thus bringing the book too close to the eyes. This habit causes a strain upon the eyes, which in time causes such changes that the eyes, which at first had normal vision, can after a time see clearly only objects that are close by. Those who live out of doors, and who do little or no reading, seldom have this trouble; they are constantly looking at objects more or less distant from them. We should not be likely to become nearsighted if we always held our books fourteen inches or more from our eyes. How close do you hold your book when reading or writing? If you cannot see clearly without holding your book within six or eight inches, you are either nearsighted, or are likely to become so. Your eyes should be examined by an oculist.

Farsightedness. — Other defects in the shape of the eyeball and the lens produce **farsightedness,** and still

other defects cause a trouble called **astigmatism,** both of which interfere with clear vision.

Color Blindness. — There are some people who, because they cannot distinguish between the most common colors, are said to be color blind; the colors most frequently confused by them are reds and greens. Their vision may not be impaired in any other way, and frequently they do not know of the defect.

The Care of the Eyes. — 1. *Use the eyes,* for it certainly does them no harm to be exercised; they were made for use. Constant use on close work such as reading or embroidery tires them, and too long a strain may injure them. The remedy, however, is a simple one. Close the eyes occasionally for a moment, or look at some distant object. This will give rest to the muscles that have been keeping the eyes focused too steadily in one position.

2. *Control the light.* Never abuse the eyes by reading in a dim light, or worse still, in a flickering light. The flickering light of the steadiest "movies" is certainly bad for the eyes, and while a little of it may not do serious harm, children who frequent the "movies" are surely laying the foundation for eye troubles. When we read, the light should fall upon the book and not into our eyes. Preferably the light should come from above, and from over the left shoulder; but a very bright light, like the sun's direct rays, should not be allowed to fall upon the book. Daylight is better than artificial light and white light better than light of any other color.

3. *Hold the head erect when reading.* To read in a reclining position is taxing to the eyes and does them injury. If the brain is really fatigued, it is a bad plan to

read while lying down. This means setting the tired brain a new task, that of controlling the work of the eyes, and under conditions bad for the eyes themselves. It is better to give the brain a shorter but more complete rest by lying down with the eyes closed for a few moments.

4. *Watch the eyesight.* If there is difficulty in seeing, if the eyes become inflamed, or if there is a tendency to headache, the eyes should be examined by an oculist. Headaches that are due to eye trouble are often cured by the use of glasses prescribed by a competent oculist.

5. *Remove dust particles* that get into the eyes. Usually bits of dust are washed away by the tears and carried into the tear duct. If not dislodged in this way, they may frequently be dislodged by lifting the upper eyelid with the fingers and drawing it down over the lower eyelid. If not, some competent person can usually discover where the particle of dust is, and can remove it with the end of a soft handkerchief rolled up to a point. If this attempt fails, a physician should be asked to attend to it, as the particle should not be allowed to remain. In such cases the natural flow of tears is increased, to help in removing the trouble, the eye becomes inflamed, and there is temptation to try to rub the particle out; that will only increase the difficulty. *Never rub the eyes.* Any one who has eye trouble should consult a physician or an oculist at once. Failure to do this often means lifelong trouble. The eyes are so infinitely important to us that they should be guarded with every care. Never have them treated by incompetent people.

Diseases of the Eyes. — *Pink eye* and *trachoma* (or granulations) are two rather common diseases of the eye,

Both of these diseases are contagious and are often communicated by the use of a public towel.

QUESTIONS

1. Distinguish between general sensations and special sensations.
2. Can you see why the eye needs to be a very much more complex organ than are the sense organs of touch?
3. What is the shape of the eyeball? How much of it can one see?
4. Why do we have eyelids? Eyelashes? Eyebrows? What does the flow of tears usually accomplish?
5. Why do you think one's eyes are often inflamed and watery when one has a cold?
6. In how many directions can you turn your eyes? How are these movements made possible?
7. What part of the eye corresponds to the "dark chamber" of a camera? What corresponds to the lens of the camera? What part corresponds to the sensitive plate?
8. Do the lenses of the eye have to be focused? Are we conscious of this?
9. Watch your cat's eyes. How do they look on a bright day? On a cloudy day? At night? Account for the changes.
10. Do you think there are pictures in the brain of all the objects you have ever seen? Why?
11. Why is it advisable for a person who is reading to look away from his book occasionally?
12. Do you know any one who is nearsighted? Any one who is farsighted? Do they wear the same kind of glasses?
13. What might happen if the engineer of a train were color blind?
14. Write a set of rules that one should follow if he would avoid eye troubles.
15. About how far from the eyes should the book be held?

CHAPTER VI

THE PART PLAYED BY THE SPECIAL SENSES (Continued)

Hearing and Other Senses

The Organ of Hearing. — We never see the real organ of hearing, the **inner ear**, for it is embedded in bones inside the head. The hardest bone in the body, called the stony bone, surrounds this inner ear, and gives it great protection from injury.

The outer parts of the ear, the bits of cartilage covered with skin which are commonly called the ear, probably help to collect air waves and to intensify sounds.

Structure of the Ear. — From the outer ear we see an opening that leads to a slightly bent passage, which is kept moist by the sticky secretion that we know in its hardened form as *earwax*. The passage is closed at the inner end by a tough, elastic membrane, the *eardrum* (**tympanic membrane**), which is stretched across it. Beyond the membrane there is a small cavity, often called the **middle ear**, on the lower side of which is an opening leading into the **Eustachian tube**. This tube, extending into the throat, is opened every time we swallow; in this way the middle ear is kept filled with air, and the air pressure within and without is kept the same. If the air pressure outside were greater than the pressure inside, the tympanic membrane would be pushed in, while it would be pushed out if the pressure within were

greater. In either case the hearing would be affected. The purpose of the tube is to equalize the air pressure.

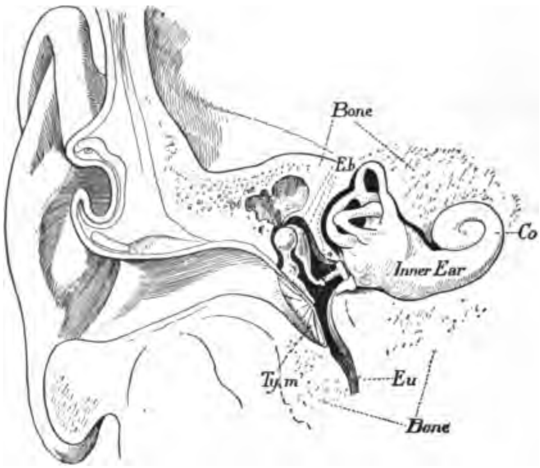


FIG. 92. — THE HUMAN EAR.

Shown in section. *Co.*, cochlea (location of the real hearing organ); *E.b.*, ear bone; *Eu.*, Eustachian tube; *Ty.m.*, tympanic membrane.

How We Hear. — Across the cavity of the middle ear are stretched the three small bones which appear in Figure 92. The outer of these ear bones is attached to the ear-drum and the inner bone connects with the inner ear, which contains the real hearing organ. The three bones are so connected that when waves of air enter the ear, the tympanic membrane is set to vibrating. This vibration is carried to the bone which is attached to the tympanic membrane and thence through the other two bones to the inner ear, where it reaches many nerves. The effect of the vibration upon these nerves is to start nervous impulses

which travel rapidly to the brain, and there produce a sensation which we call **hearing**.

What Hearing Tells Us. — Our ears give us many bits of useful information concerning the world. They tell us something of distance; for if we know what causes a certain sound, we can judge how far away it is by its loudness. Comparative loudness is our only clew to sound distances.

We cannot be at all accurate in determining the *direction* from which sound comes. If it sounds louder in one ear than in the other, we reason that the sound comes from the side where it seems loudest.

By practice we learn to discover many wonderful and valuable things by means of what the ears tell us.

Care of the Ears. — The ears require chiefly to be let alone; if they need care, it is usually such as only a physician should give. The earwax which accumulates in the outer passage may need to be removed because it is unsightly. To remove it, the end of the little finger or a rolled end of a handkerchief can safely be used, but pointed objects, like pins or needles, should never be used, except by a physician. There is danger of injury by perforating the membrane of the eardrum. Boxing children's ears may injure the membranes. Sometimes very loud noises, like explosions, will break the membrane and cause deafness.

Slight pain in the ears, caused by a slight inflammation in or around the Eustachian tube, may frequently be relieved by the application of hot cloths or a hot water bag, both of which serve to call some of the excess blood from the inflamed part to the surface.

Serious earache in children is usually caused by sores

in the ear; these occasionally make little holes through the membrane, which interfere somewhat with hearing. A physician might prevent this, if consulted in time.

A cold in the head sometimes causes slight temporary deafness. The inflammation in the throat partly closes the opening from it into the ears. Throat troubles are apt to extend to the ears and are the most common causes of deafness. A physician examines the throat first when he is looking for a cause of deafness. Sometimes he finds that the person has catarrh, and sometimes that little growths, called adenoids (see page 133), block up the passage from throat to ear. When the catarrh is cured, or the adenoids are removed, the deafness frequently disappears.

Deafness and Dullness. — Frequently a pupil is apparently inattentive and dull when the only trouble is that he never hears, as clearly as others do, the questions asked or the explanations given by the teacher; so he is confused or indefinite in his answers. He does not realize that he has any difficulty in hearing, and it may never occur to his teacher or to his parents that his habitual inattention is due to a slight deafness. In all such cases the hearing should be tested, and a physician should be consulted if any defect is discovered. A dull, inattentive pupil is sometimes converted into a bright one by a visit to a competent physician.

Temporary deafness often results from colds that affect the throat, but such deafness should disappear in two or three days. If it continues, a physician should be consulted promptly, before the delicate parts of the hearing mechanism have become involved in any serious trouble.

Taste

How We Taste Things. — There are certain substances that seem tasteless to us because they do not readily dissolve in the saliva of the mouth, and so do not produce taste. Solid bodies do not give us the sensation of taste until they are more or less dissolved in the saliva. This is readily demonstrated with a solid lump of sugar, a substance which dissolves very quickly. If the tongue is rubbed dry, a lump of sugar placed upon it gives us no sweet taste until the liquids of the mouth have time to begin dissolving the sugar.

The organs of taste are located in the upper side of the tongue and in the roof of the mouth. The sensation of taste is strongest when a substance is rolled around by the tongue at the back of the mouth. By looking at the tongue in a hand mirror we see that it is covered with numerous little bunches or **papillæ**; they differ in appearance and also vary in use. Some of those at the back of the mouth are associated with the sense of taste and contain what are called **taste buds.**

The tongue is made up, for the most part, of muscles which run in many directions, thus enabling us to move it very easily. In addition to the muscles the tongue has many glands, which secrete a watery substance that keeps it moist. There are also many blood vessels and nerves, some of which are particularly concerned with carrying to the brain the messages that enable us to determine the presence of sweet, sour, or bitter substances.

If the tongue is not of a pinkish red color, it is usually a sign that the stomach is out of order. A physician

commonly examines the tongue to detect signs of trouble with the digestive organs. If it is covered with a whitish or yellowish coating, or if it is bright red, he knows that something is wrong.

Kinds of Taste. — Many sensations that we call taste are really sensations of taste and smell combined; and we are so dependent upon this combination that we cannot readily distinguish between familiar substances by the sense of taste alone. If a person closes his eyes tight and holds his nose, so that he cannot catch the least odor, it will be found that he cannot readily distinguish between apple, onion, and potato if they are given to him successively and in small pieces. When you eat your dinner, notice how much the temperature and odor of the food have to do with your enjoyment of its taste.

All tastes may be classified under four heads: bitter, sweet, acid (sour), and salt. The different tastes are not perceived equally well in all parts of the mouth; for instance, we taste sweet things most delicately at the tip of the tongue, and bitter things at the back part of the mouth. This suggests that when we have bitter medicine to take it is better to gulp it down quickly than to hold it in the back of the mouth, dreading to swallow it.

Peculiarities of the Sense of Taste. — *Taste persists* longer than most of the other sensations. When the light ceases to shine into the eye, the sense of sight is gone; the sense of sound stops when the vibration that produced it no longer affects the ear. The sense of taste, however, may last many seconds, or many minutes, after the substance tasted has been swallowed; this is partly

because small particles of the substance remain in the mouth.

The sense of taste is quickly tired. Our eyes may be used all day long, and yet we see as clearly at night as in the morning, while the sense of taste is dulled in a few minutes. Even if we eat very sparingly, food does not have such a pleasant taste at the close of a meal as at its beginning. So to obtain the most pleasure from the sense of taste we must not overgratify it. The bulk of our food should be such as satisfies the appetite. Then an occasional luxury that gratifies the taste will be more thoroughly enjoyed. Finely flavored substances, like candies, sauces, and sweets in general, should be used in comparatively small quantities. This results not only in better health, but also in greater enjoyment of such delicacies. Highly flavored food at every meal soon ceases to be a novelty. The most delicious foods, if constantly eaten, soon give less and less enjoyment.

Smelling

What Smell Is. — Only substances that are in the form of gases or vapors produce the sensation of smell. We think we can smell a liquid like strong cologne, but the only part of it that we smell is the vapor rising from it. It is almost unbelievable how small an amount of vapor is required to excite the sense of smell; if a bottle of peppermint oil is opened for a few moments, it gives off a vapor that fills the room. Something from it must have passed into the air of the room. Yet if the bottle is closed again and reweighed in the most delicate scales,

there is no perceptible difference in its weight. No other sense is as delicate as that of smell. With some animals this sense is much keener than in human beings. How wonderfully keen it must be in the dog that follows his master's footsteps, even through a crowded thoroughfare, by means of his sense of smell.

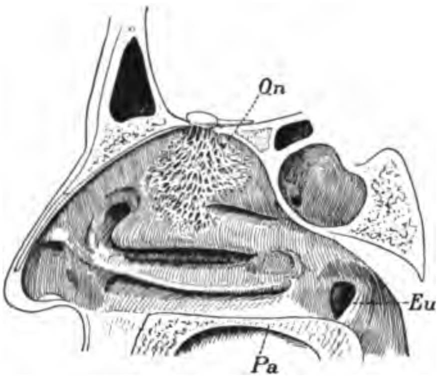


FIG. 93. — Section through the nose, showing the complex air passage. *O.n.*, olfactory nerves; *Eu.*, opening of Eustachian tube; *Pa.*, the roof of the mouth (palate).

Where We Smell. — The sense of smell is located in the nose. The nostrils lead into two large cavities above the mouth, which extend backward to the throat, and are separated from each other by a bony partition. These cavities are partly filled with thin, folded bones, so bent around as to form curved surfaces. Upon these bones, especially in the upper part, are the nerves of smell (olfactory nerves), as shown in Figure 93. Vapors entering the nose, as we breathe, act upon these nerves in such a way that they send messages to the brain, producing in the brain the sensation that we call odor or smell.

The acuteness of the sense of smell is even more quickly blunted than the acuteness of the sense of taste. The first whiff of illuminating gas gives a strong sensation, but one quickly becomes used to it. For this reason it is foolish to sit in a room when we think we smell gas.

Our perception of the odor is bound to grow less acute, so we should heed the first warning of danger and hunt for the source of the odor.

Touch and Temperature

Sight, hearing, taste, and smell are very distinct senses. A fifth sense, which is sometimes called the **sense of touch** and sometimes given the more general name of *feeling*, is really made up of several different kinds of sensations combined.

The Touch or Pressure Sense. — The nerves in the skin are very sensitive to pressure. When anything presses, even very lightly, on the skin, nervous impulses are sent to the brain. The brain interprets them and gains from the sensation some knowledge of the object that is touching the skin. It is amusing to see what mistakes will be made by a blindfolded person when various familiar objects are placed in his hands to be identified by the sense of touch alone. The whole skin is an organ of touch, although in some places it is more sensitive than in others.

In addition to the sensation that the skin is touched, we know too with considerable accuracy what part of the body is being pressed upon by the object and the amount or degree of pressure. One can tell whether a penny is lying on the palm of the hand or on one of the fingers. The sense of touch is most delicate at the tips of the fingers and at the tip of the tongue. We can locate within a twenty-fifth of an inch where a needle point touches the skin of the finger tips or of the tongue. On the back of the fingers the sense of location is much less delicate,

and it is least delicate of all on the back, at the shoulders; in fact, we cannot determine within two and a half inches where an object is touching the back of the shoulder.

This is easily tested with a pair of dividers. When you are blindfolded, let somebody touch your cheek, your finger tips, the back of your hand, and the back of your neck, sometimes with one point of the dividers and again with both points. Notice how far apart the points must be before you can distinguish whether you are being touched by one point or by both points. We can see from this that the sense of touch is the most delicate in those parts of the body in which this sense is most often stimulated.

The delicacy of this sense increases with training, as is shown by the fact that the fingers of a blind man become very much more sensitive than those of a man who does not have to depend so much upon touch for his knowledge of the world. From the sense of touch and from our ability to locate touch sensations, we get our most intimate knowledge of objects; we can tell whether they are rough or smooth, blunt or sharp, solid or liquid.

The Sense of Heat and Cold. — We know that the sensation of being hot or cold is due to tiny organs in the skin, which feel cold or hot according to the amount of blood flowing over them. With the same little organs we perceive the temperature of objects that touch or approach close to the skin. The skin in general is sensitive to both heat and cold though some spots are sensitive to heat and not to cold, others to cold and not to heat. The warm and the cold "spots" are very close together, so that we cannot commonly distinguish them.

The temperature of the skin is not the same at all points; we know that if the hand is placed on the forehead, the forehead feels warm to the hand and the hand cool to the forehead. If you were to lay on a boy's finger a metal button that was warmed to the exact temperature of his finger, he would feel the pressure of the object, but it would give him no sensation either of heat or of cold.

Our idea of the comparative temperature of different objects is frequently due to the effect they produce upon our body temperature. In cold weather we would rather jump out of bed onto a rug than to step onto the bare floor, yet floor and rug are exactly the same temperature; the difference is that the bare floor draws heat away from the feet more rapidly than the rug does. In cold weather, metal objects seem colder than cloth for the same reason; they take heat away from the body more rapidly.

General Sensations

There are many general sensations, all of which tell us something about the condition of our bodies. One of these is the sense of **hunger**, which tells us that we need food. We feel this sensation in the stomach, and it disappears as soon as we give the stomach food, although, as we have learned, it is sure to be a long time before the food eaten is ready to nourish the body. **Thirst** is another similar sensation. It is felt in the throat and disappears as soon as we drink sufficient water.

The Sense of Pain. — Almost any nerve that carries impulses to the brain will cause a sense of pain if it is strongly excited; pain is due to an overstimulation of the

sensory nerves. We can determine very closely the location of a slight pain, but not so readily the location of a severe one. A slight toothache can be located in the proper tooth, but a severe one seems to come from the entire jaw, or from the whole side of the head. We can make a slight pain seem very severe by allowing ourselves to think of it, and, on the other hand, many of our pains disappear if we try to forget them by giving our attention to something else. This is what is meant by saying that pain is largely a matter of the imagination.

Pain always has some meaning for us; it is usually a warning. The sensible thing is to find out what the warning means, to heed it, and then to make ourselves think of something else. People who do not understand the meaning of pain often make it worse by rebelling against it. But if it were not for the friendly warnings that pain gives us we should probably few of us ever live to grow up. If it did not hurt to burn the fingers, children would probably entirely destroy their fingers before they were old enough to know how to take care of them. To try to stop pain by using a "pain killer," or any drug that deadens it, is about as senseless and as disastrous in its results as to try to put out a fire by stopping the fire alarm so that we shall not be disturbed by it.

The Muscle Sense. — There is a sense which we seldom recognize, called the **muscle sense**; by it we know when and how much we contract our muscles. This sense is located in all the muscles, but especially in those of the joints. With closed eyes, we can move our fingers an inch or a foot, whichever we wish, knowing almost exactly how much the muscles are contracting. If it were not

for this important sense, one could not possibly throw a baseball accurately or make any of the complicated body motions that require the simultaneous contraction of a large number of muscles.

Perhaps you did not know that you had such a sense. To test it, rest your hand on a table and close your eyes, and see if you can tell how far a friend lifts your hand. You get the information from your muscle sense.

QUESTIONS

1. Describe the structure of the ear. Could one hear if one had no outer ear? How is the sensation of hearing produced?
2. What do we mean by sound? How does sound travel?
3. Have you ever thrown a stone into still water and watched the ripples of water that travel in every direction from the spot where the stone struck? What happens in the air when a sudden explosion occurs?
4. Does the head of a drum vibrate when it is struck? Why can one make very little noise with a drum if the head is not taut?
5. What is likely to happen if the Eustachian tube gets blocked up? Why?
6. What should one use when it is necessary to remove wax from the ear?
7. What may result from trying to frighten another person by making a loud noise near his ear? Have you ever heard of a person being deafened by a Fourth-of-July prank?
8. Name the most frequent cause of ear troubles.
9. Where are the sense organs of taste? Describe them.
10. How can you account for the fact that alum has an acid taste when placed on the tip of the tongue and a sweetish taste when pushed to the back of the tongue?
11. Explain why one who likes his food highly seasoned with salt and pepper would have to keep using more and more of these condiments as time went on.

12. Chew some pure roasted coffee, holding the nose as you do so. Then chew some without holding the nose and notice the difference in its taste.

13. Where is the sense organ of smell located?

14. Describe how it is stimulated.

15. Do you think it is very important that one's sense of smell should be acute? Cite instances to prove it.

16. A hunter when he is tracking an animal, approaches from the opposite direction from which the wind blows. Explain why.

17. Think of some experiment by which you can prove that cold, heat, and pressure are not felt by the same end organs.

18. What parts of the body are most sensitive to touch? Which are the least sensitive? Can you see any reason why nature has provided that the tips of the fingers and the lips should be especially sensitive?

19. Name some of the sensations we classify as "general." Why is it both senseless and dangerous to take medicines to deaden pain?

SECTION IV

SAFETY FIRST

PUBLIC HYGIENE

IF it were not for disease germs, their prevalence and the ease with which they are transmitted, it would be enough for us to study **personal hygiene**, the rules by which we should guide our own lives. But as things are, people are more or less dependent on others, especially in cities, where they are so crowded together that there are many opportunities for disease germs to pass from one to another, with the result that epidemics of various diseases break out, making many people ill and causing many deaths. It is nearly impossible for any one in a city unaided to guard himself securely against such diseases. It is therefore necessary that every one in the community should unite in the work of preventing the spread of disease. So for the purpose of safeguarding the public health various health regulations are adopted for the entire community. The regulations which should guide and protect every citizen in his relation to his community constitute the rules of **public hygiene** or **sanitation**.

The Public Water Supply

In a city the people must use a common water supply. Hence Water Commissions or Water Boards are appointed by cities to see that a sufficient supply of water is available and to see that it is kept pure and safe. The best sources for a large supply are the lakes and reservoirs in which the water has had a chance to stand for a long time, for in the course of a couple of months it becomes purified even though it might have been polluted originally. It is for the purpose of keeping such water pure and safe that the Water Commissioners frequently fence in reservoirs to keep people away from them.

Water from a river that receives sewage along its course is a very undesirable source for a city water supply. Sewage drained into a river near its source has been known to result in thousands of deaths from typhoid fever in towns located farther down stream which use its water for drinking purposes. Sometimes it is found impossible to obtain a sufficient supply of pure water for a large city, except from such rivers. In such cases the Water Boards endeavor to provide some method of purifying the water so as to make it safe and wholesome before allowing it to flow into the city water pipes.

One method is to filter the water. The filtering that is done in the homes so frequently by means of the small filters attached to the faucets is of little value; for while they may remove from the water particles of dirt and vegetable matter, they do not remove the disease germs; so that the filtered water, though clearer, is really as dangerous

as ever. There are, however, methods of filtering water through great beds of sand which remove the dangerous bacteria at the same time that they remove the dirt.

Sometimes another method is used. A very minute quantity of chloride of lime — about one part to a million parts of water — is added to the water as it flows into the city pipes. This is found to be sufficient to destroy the disease germs. Sometimes chlorine gas is used instead of chloride of lime. In times of special danger the Health Officials may advise the boiling of all drinking water. Such advice should always be carefully followed, for it means that the water is known to be dangerous and likely to make us ill unless boiled.

The Milk Supply

The need of protecting the milk supply has led to the appointment of Milk Inspectors and other public officials whose duty is to supervise the production and distribution of the milk. By a careful inspection of dairies and a supervision of the distribution of milk, much of the danger is removed. But with all this it still remains true that much of the milk sold is dangerous, especially to babies, partly because they are not strong enough to resist disease and partly because they live so largely upon milk. Milk for babies should therefore be of the highest quality. Some communities adopt the plan of grading the milk that is sold. Grade A is the highest grade and is safest. Grade B is less reliable and less valuable. It is recommended for general use but not for babies. Grade C is the lowest grade, and is not recommended for drink-

ing by any one. Of course Grade A milk is the most expensive, but it is worth more than it costs.

Disposal of City Wastes

The cleanliness of a community is the measure of its health. In earlier centuries little attention was paid to the various wastes; they were allowed to accumulate in the soil, on the streets, and in the gutters. Sickness was common and the death rate very high. Our modern cities have learned to take incessant care of wastes that cause bad odors, ugly sights, and disease. They require that garbage be placed in cans furnished by the householder, and the waste from them is regularly removed by city garbage wagons. These garbage cans should always be carefully covered to prevent their becoming the breeding places of flies.

Large underground tunnels, called sewers, are below city streets. Into these all the more offensive materials from our homes are conducted, which means that our homes are connected with places where there is much dangerous material. Leaks in pipes connecting sinks and closets with the sewers are a source of danger, since disease germs in the sewage may find their way through very small cracks. A careful inspection of plumbing is thus necessary for health. Sewer gas itself is not, however, as dangerous as it was once supposed to be. *The disease germs are in the sewage and not in the gas.*

What to do with all the wastes collected in the garbage cans and the wastes in the sewers has been a hard problem for cities to solve. Some of it may be burned; in cities that are near the sea it may be carried out to

sea and dumped. Sometimes cities allow their wastes to flow into neighboring rivers, which thus become more and more polluted every year. Other means of destroying sewage or rendering it inoffensive are being sought and discovered. All of these matters have to be attended to by the proper public officials, and their work, though perhaps not pleasant, is of the utmost value to the health of the community.

Fresh Air

It may seem strange that there is any need of officials to determine in what kind of houses people should live. There would be less need of such work if every one appreciated the importance of having an abundance of clean, fresh air. But many people do not appreciate this, and so they live in rooms made almost air-tight by keeping windows and doors closed, breathing over and over again the same air and inhaling the germs that may be in it.

Such homes are dangerous to all who live in the neighborhood, and public officials sometimes find it necessary to compel the occupants or the owners to make the conditions more sanitary. In large cities officials have sometimes found in a single tenement house more than a hundred cases of tuberculosis, each one of which is distributing tuberculosis germs among the neighbors. When people do not understand such dangers, it is necessary that health officers enter these places and improve the conditions.

Public hygiene also demands good ventilation in schoolrooms, factories, stores, and public halls. Plenty of fresh air wherever people congregate is an important public safeguard.

Protection from Contagious Diseases

The most important work of the public health officials is in preventing the spread of contagious diseases and in checking epidemics. In the middle ages certain contagious diseases which killed vast numbers of people were called the "scourge of God." These "plagues" would sometimes break out when thousands of people gathered from different parts of the world on a pilgrimage or for the Crusades. It was the same then in the armies; a "scourge" would break out, men would begin to die by thousands, and the only measure possible was to disband the army — which often meant that the soldiers, going to their homes, took the disease back with them. Modern armies know that they have to fight germs as well as their enemies, and they have learned to fight equally well in both kinds of warfare.

Army Precautions in 1902. — The first demonstration of the extent to which an army may be protected from its germ enemies was given by the Japanese in their war with Russia in 1902. Four years before that date, our country had been at war with Spain. Most of the facts about disease germs were known at the time of our war, but we had not learned what to do about them. The result was that for every one of our soldiers killed by bullets four died of disease. The Japanese, previous to their war, had worked out plans for using the knowledge about germs as disease makers. They sent their doctors and scientists ahead of the army to locate the healthy places for camps, to learn whether the water of the streams and wells was fit to drink, and to discover and

remove any conditions that might make the soldiers sick when they came to camp. In the Japanese army only one man died of disease for every four that were killed by the enemy. Preventable diseases almost disappeared from the army.

Army Precautions in 1914. — The armies fighting in the great European war of 1914 took these and many similar precautions. Sometimes bath trains were sent along the railroad in the rear of the army so that the soldiers, particularly those who were fighting in the trenches, might have water and facilities for bathing, because cleanliness was known to be such an important aid in preventing contagious diseases.

Community Precautions. — The fact that armies can thus be kept free from preventable diseases shows us that much could be done in our cities if similar precautions were only adopted. The difficulty is that there are always some people who do not act like good soldiers; they will not follow the directions given by the health officers, will not do what is necessary to prevent the spread of diseases. Some are so careless that they never even read the health regulations; others refuse to believe that there is any need of following them; and there are still others who do not seem to care whether they help to distribute disease or not. In a city, therefore, it is almost impossible to get the health regulations properly followed. In an army camp, on the other hand, the soldiers are trained to follow completely every order given them. As a result a camp can be kept practically free from preventable diseases, while a city cannot.

In spite of these difficulties very much is now done to

check epidemics. In former centuries there were times when, through epidemics, the death rate was just about equal to the birth rate, so that for long periods there was no increase in population. Epidemics still occur, but they are less common and less serious than they used to be and a much smaller number of people are killed by them. This is largely due to the work of the health officials. The methods adopted to fight contagious diseases are many, each one of the diseases being handled in its own way. Public officials must know how to fight each one. Only a few of the methods may be mentioned here.

By Vaccination. — Some kinds of epidemics are checked by making people more able to resist them, by the aid of vaccination. This has been done for many years to prevent *smallpox;* it is now used also to prevent *typhoid fever* and occasionally *diphtheria,* the methods used being somewhat different in the three diseases.

By Preventing the Distribution of Disease Germs. — Health officials know how the germs that cause different diseases are usually distributed. So when they have an epidemic to fight they can tell at the start the probable sources of the germs that cause it. By investigating all probable sources they can usually locate the one from which this particular epidemic comes, and then destroy the germs. Knowing that typhoid fever is distributed chiefly by water, milk, and flies, officials take steps, as soon as typhoid begins to be epidemic in any community, to guard the water, pasteurize the milk, and destroy flies and their breeding places. To stop malaria and yellow fever, they fight mosquitoes; to fight the plague,

they destroy rats; to check diphtheria, they keep out of school the children who have the germs in their throats; to check the spread of consumption, they try to prevent spitting in public places; to stop an epidemic of sore throat, they may stop the sale of milk from some one dairy which is spreading the germs.

One important step that has been taken is to discourage or forbid the public use of certain toilet articles. No one would think of using another person's toothbrush, but many people have no hesitation in using a public drinking cup or a common towel. The public drinking cup has long been condemned by health officers because it was found that through it contagious diseases may be transmitted from one person to another. The actual discovery of disease germs on such cups showed that some steps for the protection of the public should be taken. So drinking fountains were devised, with little jets of water which one could take directly from the fountain without the use of any water container; individual paper cups were also made in such inexpensive form that it is possible to provide them in quantities, allowing each person in a public place to use a fresh cup. These cups are now provided generally on railway trains and in many buildings where numbers of people congregate; schools also furnish them. Since there are so many disease germs constantly about, and since such germs are found even in the mouths of well people, it is evidently criminal foolishness not to take all reasonable precautions to prevent their transmission from one person to another.

Isolation and Quarantine. — With some contagious diseases isolation and quarantine are the means adopted

to check them. These two words are often used interchangeably. Strictly speaking, **isolation** is keeping the sick person away from those who are liable to take the disease from him; **quarantine** is keeping the patient, and those who may have been near him, from associating with others until all danger of their distributing the disease germs has passed. Various rules for this purpose have been devised. In severe contagious diseases, such as smallpox, scarlet fever, or diphtheria, where the chances of contagion are great, the patient is sometimes taken to a special hospital, where he can be more carefully attended than at home, and where there is no chance of his spreading the disease. He is thus kept away from others until he can no longer give the disease, the length of time being determined by the Health Officers.

Hospitals. — In our modern cities there are many hospitals for the treatment of disease. In them the very latest appliances for the care and comfort of sick people are to be found. In these days physicians and surgeons have devised many means of treating disease which require appliances that a physician cannot take with him to his patient's house. He has some of them in his office for use with patients who are well enough to visit him there; those who cannot do that have the same opportunities for skillful care in the hospitals, where the best of nursing and medical attendance is given.

QUESTIONS

1. What agencies are there in your town or city for protecting the public health? Name some of the things that they do. What notices have you seen posted in public places signed by the Board of Health?

2. How may the fact that a certain family lives in a damp, poorly ventilated house or uses impure milk endanger the lives of people in an entirely different quarter of the city? Mention all the ways you can think of by which diseases might be communicated from the one family to the other.

3. Have you ever seen in your town any markets where food was exposed to dirt and dust and to flies? Could anything be done to force the owner to protect the food from such contamination?

4. What can Health Officials do to protect the public from dangers that may lurk in its drinking water?

5. Explain why the future of our country depends on having a pure milk supply.

6. If you live in the country, describe how the cows which supply you with milk are cared for. Are the stables clean? Are the cows cleaned before the milking is begun? Do the men who do the milking wear the same clothes that they wore to do their other work?

7. If you live in the city and can do so, visit the dairy from which milk is supplied to you and describe conditions.

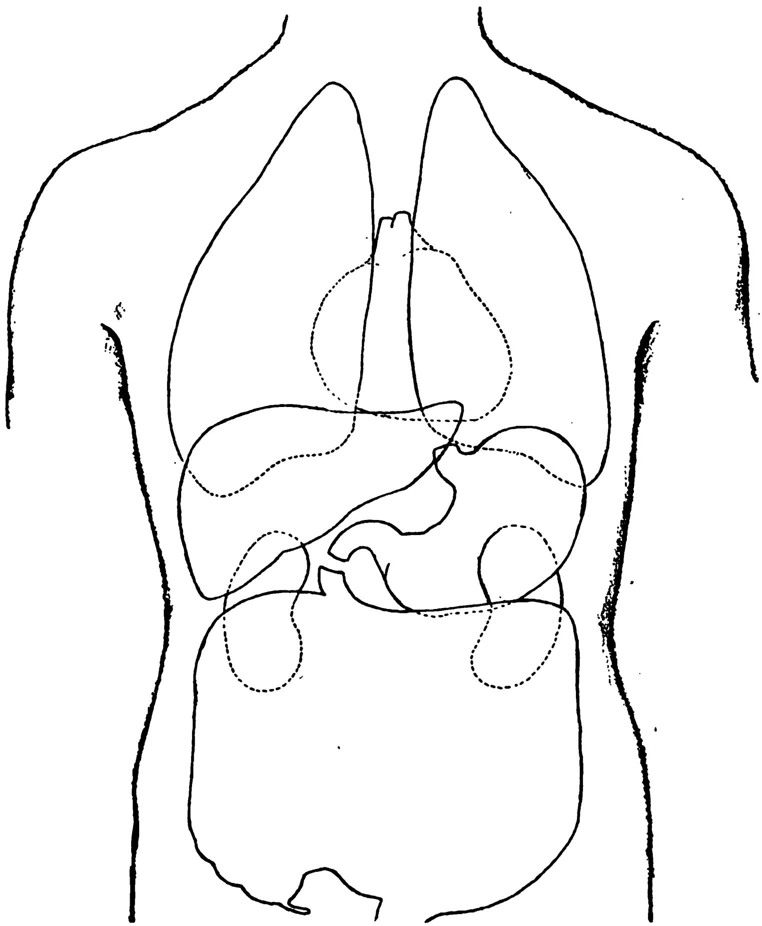
8. Write a theme on "How I can Help to Keep my Town or City Clean."

9. Find out if you can in what parts of your town or city tuberculosis and pneumonia find the most victims. Explain why.

10. Are there any model tenements in your city? Describe such a tenement.

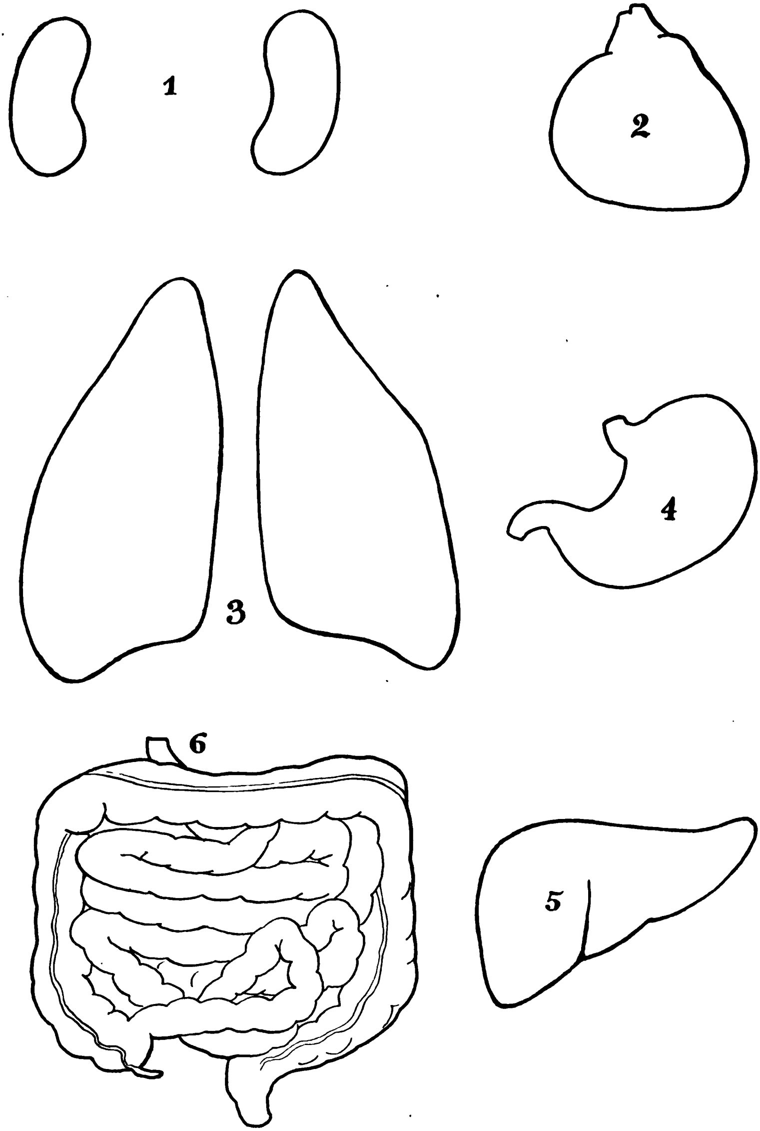
11. Do you know of any families in the country who live in stuffy rooms and sleep with their windows closed tight in cold weather? Do you often see sleeping porches in the country?

12. Describe what Health Officials are doing to prevent disease. Enumerate all the ways in which you can help them.



THE OUTLINES OF THE CHIEF ORGANS OF THE BODY IN POSITION.

This diagram is designed to help the pupil to locate these organs accurately. The best way to use it is to draw the body outline three times the size of this figure; then draw the separate organs, as given on the opposite page, three times their size there; cut out the organs drawn and place them in the body outline as drawn. The numbers show the order in which they can best be placed. When the pupil can place these organs correctly, without referring to the diagram, he knows better than many adults do where they lie and how they are related.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GLOSSARY OF TECHNICAL TERMS

The vowel symbols are those used in Webster's New International Dictionary

GUIDE TO PRONUNCIATION

ă as in *a*m	*ĕ* as in *e*nd	*ŏ* as in *o*dd	*ŭ* as in *u*p
ā as in *a*le	*ē* as in *e*ve	*ō* as in *o*ld	*ū* as in *u*se
ȧ as in sen*a*te	*ė* as in *e*vent	*ȯ* as in *o*bey	*ů* as in m*u*te
ȧ as in *a*sk	*ẽ* as in h*e*r	*ô* as in *o*rb	*û* as in *u*rn
ä as in *a*rm	*ĭ* as in *i*ll	*o͞o* as in f*oo*d	*y̆* as in h*y*mn
â as in c*a*re	*ī* as in *i*ce	*o͝o* as in f*oo*t	*ȳ* as in fl*y*

Italicized vowels have the obscure sound: *a* as in sof*a*, *e* as in rec*e*nt, *o* as in c*o*nnect, and *u* as in circ*u*s.

ăb-dō′mĕn. — The lower cavity of the body containing the stomach, intestine, and other organs.

abscess (ăb′sĕs). — A sore that comes to a head and discharges pus.

ăd′ė-noids. — Useless growths sometimes appearing in the throat or nasal cavities.

ȧ-dŭl′tẽr-ā′tion. — The debasing of a product by the addition of an impurity.

ăl-bū′mĕn. — A proteid, like the white of egg.

ăl-ĭ-mĕn′tȧ-rȳ cȧ-năl′. — A name given to the digestive tract.

***ȧ*-naē′mĭ-*ȧ*.** — A condition in which the blood is less red than usual, making a person pale.

anterior (ăn-tē′rĭ-ẽr) root. — The branch of a spinal nerve that carries messages from the brain to the muscles.

ăn′tĭ-dōte. — Anything that will counteract the effects of a poison.

ăn-tĭ-tŏx′ĭn. — A substance which neutralizes poison produced by germs.

ā-ôr′t*ȧ*. — The artery carrying blood from the heart.

är-tē′rĭ-ăl blood. — Blood that has been purified by passing through the lungs.

är′tẽr-y̆. — A blood vessel carrying blood away from the heart.

ăr-tĭ-fĭ′cial rĕs-pĭ-rā′tion. — Producing respiration by mechanical methods.

auricles (ô′rĭ-k′ls). — The chambers of the heart that receive blood from the veins.

bă-cĭl′lŭs căr′rĭ-ẽrs. — Persons who carry disease germs in their bodies though they themselves are not affected by them.

băc-tē′rĭ-ȧ. — A group of very minute plants.

ball-and-sŏck′ĕt joint. — A joint allowing free motion in all directions.

bī′cĕps. — The front muscle of the upper arm.

bī-cŭs′pĭds. — Eight of the teeth, four in each jaw, between the canines and the molars.

bīle. — The liquid secreted by the liver.

blăd′dẽr. — The sac that temporarily holds the kidney secretion.

bow′ĕls. — The intestine.

breast bone. — The bone in front of the chest.

brŏn′chī. — The branches of windpipe entering the lungs.

cā′nīnes. — Four teeth, just back of the incisors.

căp′ĭl-lā-rĭes. — The small blood vessels connecting the arteries with the veins.

cär-bō-hȳ′drātes. — A name applied to starches and sugars.

cär′bŏn dī-ŏx′ĭd. — The gas produced by burning carbon in oxygen.

cär′tĭ-lāge. — The tough flexible material that forms the softer part of the skeleton.

cā′sē-ĭn. — A proteid in milk, the basis of cheese.

cȧ-tärrh′. — A disease of the nasal cavity and throat.

cē′rē-ăls. — Foods obtained from grain, such as wheat, oats, rice, etc.

cĕr′ē-bĕl′lŭm. — The back part of the brain.

cĕr′ē-brŭm. — The highest and largest part of the brain.

cō-ăg-ū-lā′tion. — A change from a liquid to a solid condition, such as that which occurs in the white of an egg when heated.

cŏm-mū′nĭ-cȧ-ble. — Capable of being transmitted from person to person.

cŏm′pound frăc′tūre. — A broken bone with the bone protruding through the skin.

cŏm′prĕss. — A mass of soft cloth arranged with a bandage to produce pressure upon any part.

cŏn-nĕc′tĭve tĭs′sūe. — Tendons, ligaments, and other tissues that hold parts of the body together.

cŏn-tā′gious. — The type of disease that easily passes from person to person.

cŏn-trăc′tion. — Shortening.
cŏn-vō-lū′tions. — The folds in the surface of the brain.
côrds. — See *tendons.*
côrn. — A thickened portion of the epidermis (usually on a toe) caused by friction or pressure.
côr′pŭs-cle. — A small body.
crā′nĭ-ŭm. — The rounded part of the skull, containing the brain.
der′mĭs. — The inner layer of the skin.
dī′ȧ-phrăgm. — A tough, muscular membrane, separating the thorax and abdomen.
dĭph-thē′rĭ-ȧ. — A very serious disease of the throat.
dĭs-ĭn-fĕc′tion. — Destroying the germs of disease.
dĭs-lō-cā′tion. — The wrenching of bones out of position.
dĭs-tĭlled′ liq′uors (lĭk′ẽrs). — Liquors made by separating the alcohol from a fermenting substance.
dŭct. — A slender tube by which secretions are carried from a gland.
dyspepsia (dĭs-pĕp′sĭ-ȧ (shȧ)). — A disease of the digestive organs.
ear′drŭm. — The middle cavity of the ear.
ē-mĕt′ĭc. — Something which will produce vomiting.
ĕn-ăm′ĕl. — The outer hard covering of the teeth.
ĕn′zȳmes. — Substances in the digestive juices that give them power to digest foods.
ĕp-ĭ-dĕm′ĭc. — Any disease spreading among a great number of people.
ĕp-ĭ-der′mĭs. — The outer layer of the skin.
ĕp-ĭ-glŏt′tĭs. — The lid covering the opening into the windpipe.
ē-sŏph′ȧ-gŭs or **gŭl′lĕt.** — A tube extending from the throat to the stomach.
Eū-stā′chĭ-ăn tube. — A tube leading from the upper part of the throat to the middle ear.
ĕx-crē′tion. — Waste material passed from the body.
ĕx′hȧ-lā′tion. — Breathing air out of the lungs.
fat cell. — A minute drop of fat such as exists in meat.
fē′mŭr. — The bone extending from the hip to the knee.
fĕr′mĕn-tā′tion. — A change occurring in sugar solutions by which alcohol is produced.
fĕr′mĕnt′ed liq′uors. — Drinks made from simple fermented material.
fē′vẽr. — A condition in which the body temperature is higher than normal.
fī′bẽrs. — Minute threads, like those of muscles or nerves.

flăt fŏŏt. — A condition of the feet when the arch of the foot has become partly flattened out.

fū'ĕl fōōds. — Foods used to develop force or heat.

fū'mĭ-gā'tion. — Treating with fumes of gas, usually to destroy disease germs.

gall (gôl) blăd'dẽr. — A sac which collects the bile secreted by the liver.

găn'glĭ-ŏn. — A mass of nerve tissue containing neurons.

găs'trĭc juice. — The digestive fluid secreted by the glands of the stomach.

glŏt'tĭs. — The opening from the throat into the windpipe.

glucose (glōō'kōs), or grape sugar. — Sugar found, or similar to that found, in fruits.

gluten (glōō'tĕn). — A proteid derived from wheat and some other substances.

gŭl'lĕt. — See *esophagus.*

hē-mō-glō'bĭn. — The red coloring matter in blood.

hair follicles (fŏl'ĭ-k'ls). — The little pockets from which hairs grow.

hemispheres (hĕm'ĭ-sfērs). — The two halves of the cerebrum.

hī'bẽr-nāt'ĭng. — Remaining in a dormant, sleeping condition during the winter months.

hinge joint. — A joint by which the bones can move in one direction only.

ĭm-mū'nĭ-tȳ. — Ability to resist disease.

incinerator (ĭn-sĭn'ẽr-ā-tẽr). — A furnace for burning garbage, etc.

incisors (ĭn-sī'zẽrs). — The eight middle front teeth.

incubation (ĭn-kū-bā'shŭn) period. — The time between exposure to a disease and the outbreak of the disease.

indigestion (ĭn-dĭ-jĕs'chun). — Inability to digest food properly.

ĭn-fĕc'tious. — Produced by germs; such diseases are also usually contagious.

ĭn-flăm-mā'tion. — A condition of enlarged blood vessels, accompanied by heat and soreness in the inflamed part.

ĭn-hȧ-lā'tion. — Breathing air into the lungs.

ĭn-tĕs'tĭne. — The tube through which food passes after leaving the stomach.

ĭn-vŏl'ŭn-tȧ-rȳ. — Without the exercise of will power.

ī'sō-lā'tion. — Keeping a patient away from other persons to prevent his giving them disease.

jaundice (jăn'dĭs). — A disease due to liver troubles and characterized by a yellow skin.

kidneys (kĭd'nĭz). — Organs for removing certain waste products.

lăch'rȳ-măl dŭct. — The duct which carries tears from the eyes to the nasal cavities.

lăch'rȳ-măl glănd. — The gland that secretes the tears.

lăc'tē-ălș. — Small tubes that carry fat from the intestines to the blood vessels.

larynx (lăr'ĭnks), or **Ad'am's ap'ple.** — An enlarged part of the windpipe containing the vocal cords.

lē-gū'mĭn. — A proteid found in beans and peas.

lĭg'ȧ-mĕnts. — Bands of white connective substances, which join bones.

lĭg'ȧ-tūre. — A band drawn tightly around some part of the body to stop bleeding.

līme. — A mineral substance for making bone.

lĭv'ẽr. — A large red gland lying near the stomach.

lŭngs. — Two organs in the chest cavity which absorb oxygen and give off carbon dioxid.

lymph (lĭmf) ves'sel. — A minute tube that carries lymph.

mȧ-lā'rĭ-ȧ. — A disease accompanied by chills and fever.

marrow (măr'ō). — A fatty material in the middle of the long bones.

mė-dŭl'lȧ. — The lowest part of the brain.

mĕm'brāne. — Soft tissue in the form of a sheet or a layer covering some part of the body.

mō'lȧrs. — The large back teeth, twelve in number.

mŭmps. — A disease accompanied by swollen jaws and cheeks.

muscle (mŭs''l) fī'bers. — The microscopic threads of which muscle is made.

mȳ'ō-sĭn. — A proteid found in meat.

när-cŏt'ĭc. — A drug that dulls body action.

nasal (nā'zăl). — Pertaining to the nose.

nerve (nûrv) fī'bers. — The microscopic threads of which a nerve is composed.

nerves. — Long bundles of fibers that carry messages in the body.

neū'rŏns. — The irregular nerve cells that are found in the brain and spinal cord.

neū'trăl-īze. — To counteract or destroy the effect of.

nutritious (nū-trĭsh'us). — Capable of building up the body or furnishing it with heat or force.

ŏx'ĭ-dā'tion. — A union of some substance with oxygen.

oxygen (ŏk'sĭ-jĕn). — A gas forming one-fifth of the air.

păn'crḗ-ăs. — A large gland which secretes a fluid to digest proteids, starches, and fats.

pȧ-pĭl'lȧ. — A minute, finger-like projection.

păr'ȧ-site. — An animal or plant that lives on the body of another animal or plant.

pȧ-rŏt'ĭd glănds. — The salivary glands in front of the ear.

pasteurization (pȧs'tĕr-ĭ-zā'shŭn). — Heating food (milk) to a temperature of about 145° to destroy disease germs.

pĕp'sĭn. — An enzyme secreted by the stomach.

plasma (plăz'mȧ). — The liquid part of the blood.

pneumonia (nů-mō'nĭ-ȧ). — A very serious disease of the lungs.

pōres. — Small openings in the skin through which the sweat passes.

posterior (pŏs-tē'rĭ-ĕr) root. — The branch of the spinal nerves which carries messages from the skin and muscles to the brain.

preservatives (prḗ-zûr'vȧ-tĭves). — Chemical substances added to food materials to prevent their spoiling.

prō'tḗ-ĭds. — Foods useful for building body tissue, such as albumen.

ptomaines (tō'māns). — Poisons produced in spoiled foods by bacteria.

pŭl'mṓ-nȧ-rў̆ är'tē-rў̆. — The artery which carries blood from the heart to the lungs.

pŭl'mṓ-nȧ-rў̆ cir-cu-la'tion. — The circulation of the blood from the heart to the lungs and back.

pŭlse. — A wave of pressure that passes along the arteries with each heartbeat.

pū'pĭl. — The circular opening in the front of the eye that allows light to pass into the eye.

pŭs. — A creamy matter which is discharged from sores, boils, and other inflamed parts of the body.

pū'trḗ-fȳ. — To undergo decomposition, resulting in very unpleasant odors.

pȳ-lŏr'ĭc valve. — The valve that closes the stomach from the intestines.

quarantine (kwŏr'ăn-tēn). — The prevention of persons who are likely to carry disease germs from mingling with other people.

răb'ĭd. — Suffering from rabies, or hydrophobia.

rē'flĕx ăc'tions. — Actions that take place without the exercise of the will.

rĕn'nĕt. — A ferment secreted by the stomach, which curdles milk.

rĕs'pĭ-rā'tion. — The absorption of oxygen and elimination of carbon dioxid by the lungs.

rĕt′ĭ-nȧ. — The sensitive surface at the back of the eye.
sȧ-lī′vȧ. — The secrètion that moistens the mouth.
săl′ĭ-vȧ-rȳ glănds. — The glands that secrete saliva.
scär′lĕt fē′vẽr. — A disease characterized by a pinkish eruption of the skin.
sē-crē′tion. — Material produced by a gland for the use of the body.
sĕm′ĭ-lū′nȧr vălves. — Three valves in the large arteries near the heart.
sĕn′sȯ-rȳ nerves. — Nerves that carry messages to the brain resulting in sensations.
sewage (sū′ȧj). — The liquid material which contains the various discharges and wastes from our houses.
spe′cial sens′es. — The senses that tell us of objects outside our bodies.
spī′năl côrd. — The part of the nervous system which is encased by the backbone.
spī′năl nerves. — Nerves arising from the spinal cord.
spīne. — The name given to the backbone.
splēēn. — A gland in the abdomen.
sprāin. — The tearing or straining of ligaments at a joint.
spū′tŭm. — Matter spit up from the throat or lungs.
stärch grains. — The minute bits of starch as they are found in the potato and other raw foods.
stĕr′ĭ-līz-ĭng. — Heating a substance until all living organisms (bacteria) are killed.
stĭm′ū-lŭs. — A shock that causes a muscle or other organ to act.
sŭf′fȯ-cā′tion. — Stopping of breathing by closing the windpipe or by some other means.
taste buds. — The organs of taste in the tongue.
tĕn′dŏns. — Bands of white substance uniting muscles with bones.
thō′răx. — The chest.
thrōat. — The cavity at the back of the mouth into which the mouth and nose open.
tŏn′sĭls. — Two rounded bodies at the back of the mouth.
tŏn-sĭl-lī′tĭs. — A disease of the throat, accompanied by sore throat and fever.
tŏx′ĭn. — A poison produced by a germ.
trā′chē-ȧ. — The windpipe.
tū-bẽr-cū-lō′sĭs. — A disease produced by a certain germ, consumption being its common form.

tўm-păn'ĭc mĕm'brāne. — A membrane stretched across the passage leading to the ear.

ū'rē-ȧ. — The chief waste product of muscle action, secreted by the kidneys.

ū-rē'tẽr. — The duct leading from the kidney to the bladder.

vaccination (văk'sĭ-nā'shŭn). — Treatment designed to prevent smallpox. Sometimes used as a means of protection against some other diseases.

vălve. — A mechanism to open and close a passage.

vein (vān). — A blood vessel carrying blood toward the heart.

vĕn-tĭ-lā'tion. — The procuring of proper amount of air in rooms.

vĕn'trĭ-cles. — The chambers of the heart that send blood into the arteries.

vertebra (vûr'tė-brȧ). — One of the bones composing the spine.

vĭl'lī. — Little projections on the inside of the intestine for absorbing food.

vō'căl côrds. — Two membranes in the larynx whose vibrations produce the voice.

whōōp'ĭng cough. — A disease characterized by violent coughing.

yēast. — Microscopic plants that cause the fermentation of sugar.

yĕl'lōw fē'vẽr. — A disease common in tropical countries; carried by mosquitoes.

INDEX